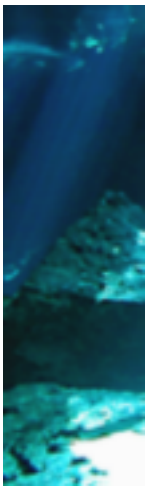
VBT™ 1.10



Visual Bottom Typer

User's Guide

DRAFT

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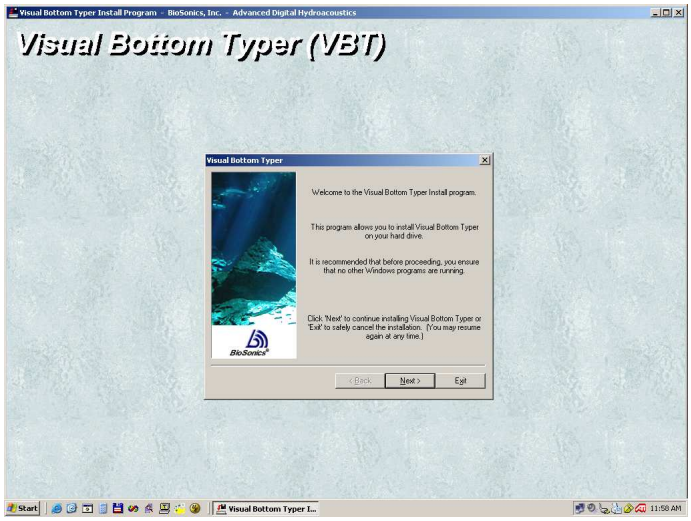
1. Insert BioSonics, Inc. VBT™ - SeaBed Classifier installation disk into your CD-ROM drive. (If the installation program does not begin automatically, browse to your CD-ROM drive and double-click on 'setup.exe')

   The following window will appear:

2. Select 'Next'


Visual Bottom Typer Install Program - BioSonics, Inc. - Advanced Digital Hydroacoustics
Visual Bottom Typer (VBT)
Visual Bottom Typer
Welcome to the Visual Bottom Typer Install program.
This program allows you to install Visual Bottom Typer on your hard drive.
It is recommended that before proceeding, you ensure that no other Windows programs are running.
Click 'Next' to continue installing Visual Bottom Typer or 'Exit' to safely cancel the installation. (You may resume again at any time.)
< Back
Next >
Exit
BioSonics
Start
Visual Bottom Typer I...
11:58 AM

3. Select 'I Accept'. You must accept the license agreement in order to install BioSonics, Inc. VBT™ - SeaBed Classifier . (A copy of the license agreement is provided on Page x).

License Agreement
Visual Bottom Typer (VBT) (TM)
END-USER LICENSE AGREEMENT
Introduction:
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BioSonics
< Back
I Accept
Exit

4. Select 'Next' to install VBT in the default directory, C:\BioSonics\VBT. Select 'Yes' if prompted to create a new directory.

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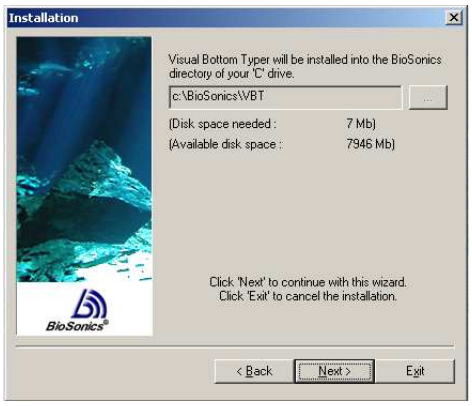
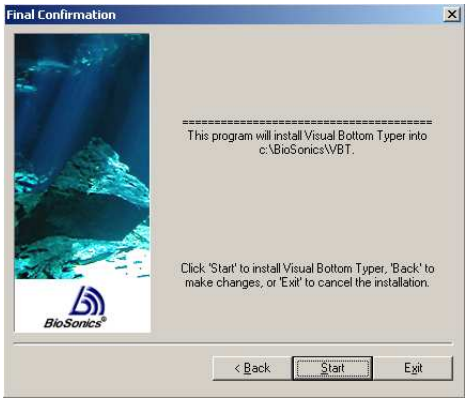
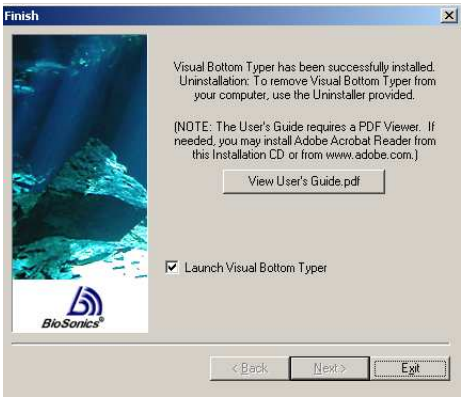

Installation
Visual Bottom Typer will be installed into the BioSonics directory of your 'C' drive.
c:\BioSonics\VBT
(Disk space needed : 7 Mb)
(Available disk space : 7946 Mb)
Click 'Next' to continue with this wizard.
Click 'Exit' to cancel the installation.
BioSonics
< Back
Next >
Exit

5. Select 'Start' to begin installation. Installation will take a few seconds.


Final Confirmation
This program will install Visual Bottom Typer into c:\BioSonics\VBT.
Click 'Start' to install Visual Bottom Typer, 'Back' to make changes, or 'Exit' to cancel the installation.
BioSonics
< Back
Start
Exit

6. Select 'Exit' to finish installation and start BioSonics, Inc. VBT™ - SeaBed Classifier . If there were no errors, you have successfully installed VBT-Seabed Classifier on your hard drive.


Finish
Visual Bottom Typer has been successfully installed.
Uninstallation: To remove Visual Bottom Typer from your computer, use the Uninstaller provided.
(NOTE: The User's Guide requires a PDF Viewer. If needed, you may install Adobe Acrobat Reader from this Installation CD or from www.adobe.com.)
View User's Guide.pdf
Launch Visual Bottom Typer
BioSonics
< Back
Next >
Exit

7. You can launch VBT using the shortcut on your desktop. The VBT program, User Guide, End-User License Agreement and Uninstaller

Program can be found in your start menu: Start ▷ Program Files ▷ BioSonics ▷ Visual Bottom Typer (VBT), as well as the installation directory C: \BioSonics \VBT.

8. Please go to: C:\Windows and create a copy of the file 'VBT.ini'. Name the copy VBT_default.ini and store it in the same directory. This will allow you to restore the default VBT settings in the future. A copy of the file is included in Appendix D.

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Acronym Guide

B1	Bottom Classification Method 1 - First Echo Normalization
B2	Bottom Classification Method 2 - First/Second Bottom Ratio (E1/E2)
B3	Bottom Classification Method 3 - First Echo Division (E1′/E1)
B4	Bottom Classification Method 4 - Fractal Dimension (E1/FD)
E1	Second Part of First Bottom Echo
E1′	First Part of First Bottom Echo
E2	Second Bottom Echo
FD	Fractal Dimension (of echo envelope)
NMEA	National Marine Electronics Association format (for longitude and latitude)
S	Bottom Classification Method - Sediment
TVG	Time Varied Gain (0, $20 \log R$, $40 \log R$)
VBT	BioSonics, Inc. VBT™ - SeaBed Classifier

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Chapter 1

Getting Started

1.1 Introduction

BioSonics, Inc. VBT™ - SeaBed Classifier can be used to determine the composition of the seabed or any other body of water (natural or artificial). Bottom-typing is accomplished through analysis of the bottom echo signal using any of four peer-reviewed algorithms as outlined in Table 1.1. (The complete references for the classification methods are provided in the Bibliography on Page 113.)

This user's guide demonstrates how to use BioSonics, Inc. VBT™ - SeaBed Classifier to classify the bottom structures present in your hydroacoustic data. Chapter 1 contains an introductory tutorial for VBT™ as well as descriptions of the toolbar and menubar options. Chapter 2 includes in-depth tutorials for creating a ground-truth library, as well as analyzing a data file. Chapter 3 describes how to manipulate each of the windows used in VBT™ . Chapter 4 provides a brief description of the algorithms included in VBT™ work.

It is not necessary to read the guide from cover-to-cover. In order to maintain chapter independence, we have repeated important points throughout the text. Information that is only provided once is cross-referenced in related

Table 1.1: Summary of Bottom Classification Methods

Method	***Echo Signal Feature Used for Classification***	***Means of Comparison with ground-truth data***
B1	Cumulative Energy Curve of the First Bottom Echo [1, 8]	Least-Squared Error
B2	Energy Ratio(E1/E2) of the Second Part of the First Bottom Echo and the Second Bottom Echo [3, 7]	Cluster Analysis
B3	Energy Ratio($E1'$/E1) of the First and Second Parts of the First Bottom Echo [2]	Cluster Analysis
B4	Ratio of the Fractal Dimension of the envelope of the first bottom echo energy (E1/FD) [5, 9, 10]	Fractal Dimension & Cluster Analysis

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sections. For first time users, we recommend reading through the introductory tutorial in Section 1.5. If you are familiar with VBT™ , we recommend practicing with the tutorials in Chapter 2. Advanced users are referred to Chapter 3 for information on maximizing the accuracy of your bottom-typing results.

1.2 Data Collection Guidelines

In order to determine the bottom-type using VBT™ the user must first collect a standard library of hydroacoustical signals (while simultaneously physically determining the bottom-type). The physical identification establishes a "ground-truth" library, which will be used as the gold standard to classify the bottom-type encoded in subsequent echo signals.

It must always be kept in mind that software-based classification is the final step in a field methodology that takes careful planning and execution. During data acquisition, please keep in mind the following guidelines:

- Data collection with a factory calibrated echosounder
- Deploy the transducer from a stable towed-body. Use an orientation sensor [1] to measure off-axis pitch, roll and yawn (and correct for any deviations)
- Maintain a boat speed that minimizes off-axis deviations
- Collect data during calm weather
- Conduct a preliminary bathymetric study of the survey area and record bathymetric gradient locations
- Lay transects along bathymetric isolines (wherever possible) with the transducer central axis adjusted to maintain orthogonality to the bottom slope
- Additional data should be collected in areas of steep slope, or that these be surveyed with the transducer central axis adjusted to maintain orthogonality with the bottom slope

[1] BioSonics, Inc. manufactures the DT-X^{IOS} with integrated orientation sensor for this purpose

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An in-depth discussion of proper field methodology is beyond the scope of this guide[2]. We recommend the following data acquisition parameters when working with bottom-typing methods B2, B3, and B4:

Pulse Duration= .4 ms

Sampling Frequency= 120 kHz

We recommend the following data acquisition parameters when working with bottom-typing method B1:

Pulse Duration= .2 ms

Sampling Frequency= 240 kHz

√ Note: Echo signal parameters depend not only on bottom-type but also on the data acquisition parameters (i.e. transducer frequency, beam width, pulse length, etc). As such, the ground-truth data are valid for a particular set of equipment and for particular equipment parameters. Extrapolating to different equipment and/or parameters should be accompanied by additional testing.

1.3 Using VBT-An Overview

The echo signal from an underwater acoustic pulse contains information after the bottom-type, as well as the sediment layer. In addition, the echo itself causes subsequent bottom echoes. BioSonics, Inc. VBT™ - SeaBed Classifier determines the top of bottom by first separating the components of the echo signal (sediment echo, first bottom echo (later divided into two parts) and second bottom echo). Once the components of the echo signal have been isolated, the VBT determines the bottom type according to the user-specified signal analysis method. VBT includes four independent analysis methods, each of which classifies the bottom using different parts of the echo signal.

Algorithm based classification is a sophisticated subject with a wealth of techniques available to the investigator. For this reason, the BioSonics, Inc.

[2]You may contact BioSonics, Inc. directly for further discussion of proper field methodology

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VBT™ - SeaBed Classifier signal analysis software can seem overwhelming to the beginning user. In this chapter, you will become familiar with the various windows, views, and commands needed to perform bottom classification. Later chapters will provide hands-on tutorials in classifying real data and exporting the results in an import-friendly format.

There are four principal viewing windows in which you may explore viewing your data and the results of VBT™ 's bottom classification analysis: (i) oscilloscope windows, (ii) echogram windows, (iii) output windows, (iv) map windows.

When a data file is first opened in VBT, it is displayed in an oscilloscope window (Figure 1.3). Oscilloscope windows show the echo envelope for all pings included in the data file, one ping at a time. Depth (range) is shown along the horizontal axis, with signal intensity in decibels along the vertical axis. The headerbar indicates the number of the ping being displayed, the total number of pings in the data file, and which transducer channel is active. The data file name is displayed in the title bar. See Section 3.1 for more information on working with the oscilloscope window.

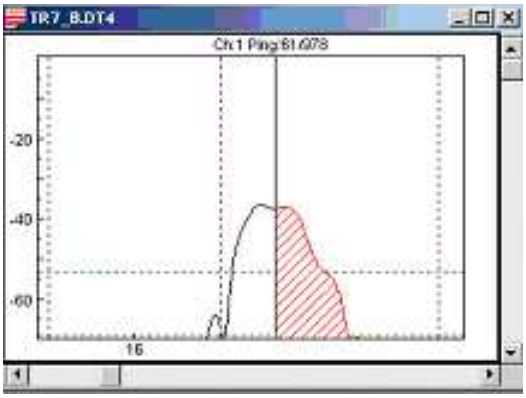

Figure 1.1: An example of the oscilloscope window from sample library file *TR7_B.dt4*. The title bar displays the file name. The heading below 'Ch: 1 Ping 61/978' indicates that the 61st ping (out of 978 pings) from Channel 1 is displayed.

When the data is being processed, two more windows open, the echogram window and the output report window. The echogram window displays all of the pings in the data file. Each vertical line corresponds to a single ping and the color of each line represents the echo intensity. Depth is shown on the left-hand vertical axis, the intensity colorbar is displayed on the right-hand vertical axis, the top horizontal axis corresponds to the ping number, and the bottom horizontal axis displays the color-coded results of the bottom classification where the colors are defined in the method windows.

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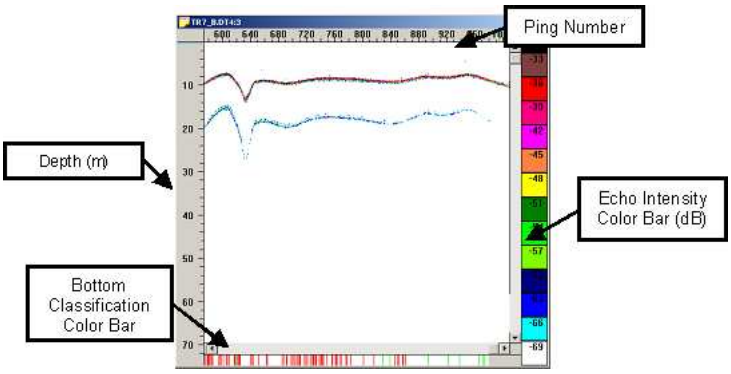

Figure 1.2: An example of the echogram window from sample library file *TR7_B.dt4*.

See Section 3.3 for more information on working with the echogram window.

The output report window (Figure 1.3) displays a table of the analysis results.

TR7_B.DT4:2

Ping	Date	Time	Latitude	Longitude	Depth	Type	E0	E1	E2
871	10/11/95	02:02:12.00	47°42.740000N	122°37.890000W	7.87	0	5.05e-006	4.75e-003	1.(
891	10/11/95	02:02:32.00	47°42.750000N	122°37.900000W	7.80	0	5.00e-006	3.81e-003	1.3
911	10/11/95	02:02:52.00	47°42.760000N	122°37.910000W	7.46	0	5.00e-006	3.82e-003	1.9
931	10/11/95	02:03:12.00	47°42.810000N	122°37.940000W	7.71	0	5.00e-006	2.91e-003	1.(
951	10/11/95	02:03:32.00	47°42.830000N	122°37.950000W	8.53	0	5.00e-006	1.47e-003	1.(

Figure 1.3: An example of the output report window from sample library file *TR7_B.dt4*.

The output report window is organized by 'ping number' and displays the data numerically for the following fields:

Date - date the data was collected

Time - time the ping was recorded

Latitude - latitude of the ping transmission

Longitude - longitude of the ping transmission

Depth - depth to the bottom

Type - numerical code corresponding to the type of bottom.

- **0** no bottom coded
- **1** corresponds red parameter box (first file opened)
- **2** corresponds to the green parameter box (second file opened)
- **3** corresponds to the blue parameter box (third file opened)

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E0 - energy of sediments echo

E1 - energy of second part of 1st bottom echo

E2 - energy 2nd bottom echo

E1′ - energy of first part of 1st bottom echo

Sediment - thickness of the sediment layer

FD - Fractal dimension

See Section 3.4 for more information on working with the output report window.

A fourth window, map window, can be opened manually by the user by selecting the `Show Map Window` command from the VIEW MENU or EDIT MAP MENU. Map images can be imported into VBT™ using the EDIT MAP Menu located in the menubar. (See Section 3.5 for more information on working with the map window.)

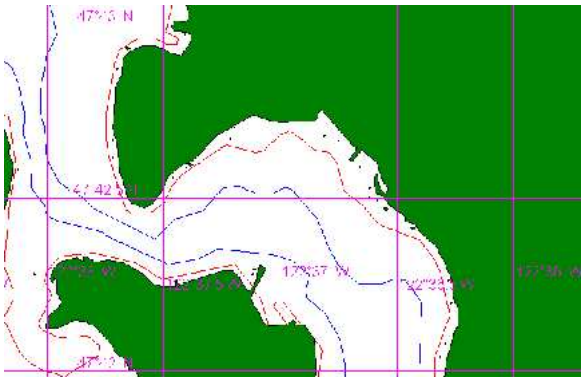

Figure 1.4: An example of the map window from sample library file *TR7_B.dt4*.

A fifth set of windows, referred to as the method windows, allows the user to customize the settings for the bottom-typing method in use. There is one method window for each bottom-typing method: B1, B2, B3, B4, S. (See Section 3.2 for more information on working with the method windows.)

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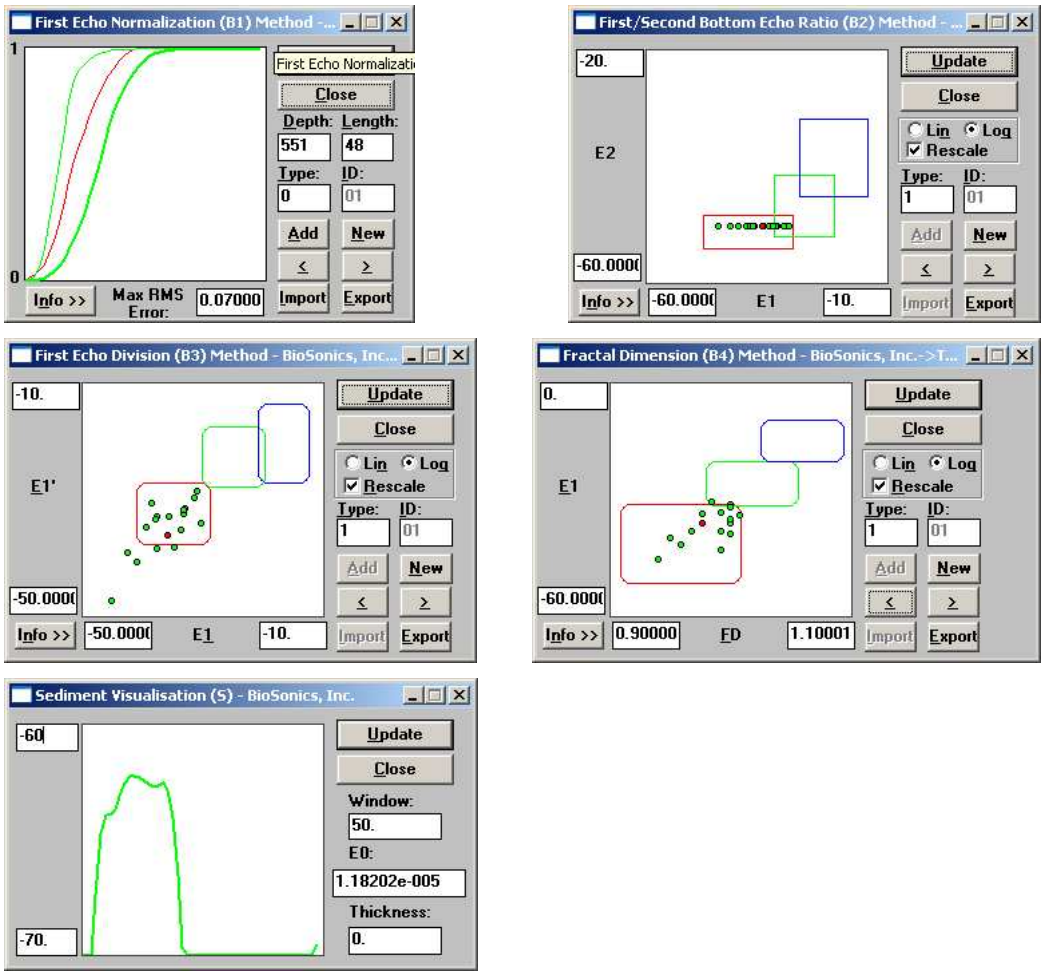

Figure 1.5: The five method windows available in VBT™ .

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Table 1.2: Sample library included with VBT™

Filename	File type	Sampling Frequency	Bottom-Type
Mud120.dt4	verified bottom data file	120kHz	mud
Mud420.dt4	verified bottom data file	420kHz	mud
Sand120.dt4	verified bottom data file	120kHz	sand
Sand420.dt4	verified bottom data file	420kHz	sand
Rock120.dt4	verified bottom data file	120kHz	rock
TR7_B.dt4	transect data file	120kHz	all

Filename	File Type
TR7B2.TXT	output report from TR7_B.dt4 analyzed with method B2
TR7B3.TXT	output report from TR7_B.dt4 analyzed with method B3
TR7B4.TXT	output report from TR7_B.dt4 analyzed with method B4
B_234.XLS	comparison of bottom classification results using methods B2, B3, and B4 on transect TR7_B.dt4.

1.4 Sample Library

VBT™ requires that the user provide a reference catalog of physically verified data files referred to as the "ground-truth" library. The VBT™ software package includes a small reference catalog containing ground-truth data files for sand, rock, and mud collected in Liberty Bay near Seattle, Washington, USA using two different acoustic frequencies: 120 kHz, and 420 kHz. Divers physically verified the bottom-types. A sample transect is also provided in order for you to explore VBT™ bottom classification methods. The complete training set can be requested from BioSonics, Inc. .

Table 1.2 summarizes the characteristics of the reference catalog provided with VBT™ and stored in C:\BioSonics \VBT \CTLG). We recommended that you practice VBT classification with the reference catalog and the sample transect before moving analyzing your own data.

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1.5 Basic Steps for Analyzing a Data File in VBT™

The following introductory tutorial outlines the basic steps for working with a data file VBT™ and does not define significance of the parameters discussed. This tutorial assumes that a ground-truth library has been previously established. Please refer to the cross-referenced sections for in-depth explanations and recommendations for each step.

In order to analyze a file using VBT™ , the following steps need to be taken: (1) load the data file, (2) prepare the data file for analysis, (3) analyze the data file (4) interpret the analysis results and (5) export the analysis results[3]. Preparing the data file for analysis is an important step toward accurate bottom-typing results.

Step 1 Loading a Data File

Step 1a Open data file *sandD120.DT4* (found in the CTLG folder). There are three ways to open a data file:

i Select 'open file' icon in the toolbar.

Open File

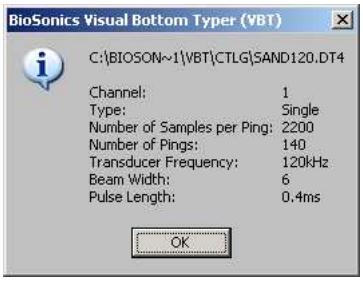
– or –

ii Select 'Open' in the FILE MENU

– or –

iii Press CTRL+O with your keyboard

Step 1b When you open a data file, a pop-up window will appear listing the data acquisition parameters for the file. Click 'OK'. You may refer back to the data acquisition parameters by selecting `Data File/Transducer Properties` in the CONFIGURATION MENU



Step 1c The data file will be displayed graphically in an oscilloscope window (shown in the following figure). The oscilloscope window plots the intensity (in decibels) of the echo signal

[3]Exporting the results is based on the user preference and is not required.

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with respect to depth (in either sample or meters). You will use the oscilloscope window to specify sampling windows and sampling thresholds while preparing the data file for analysis

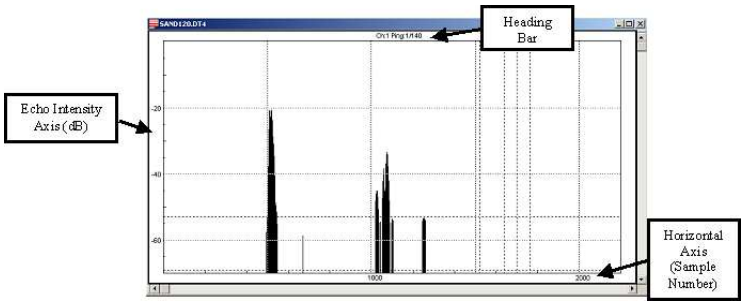
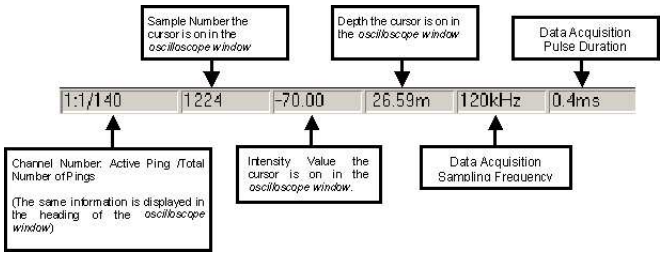


Figure 1.6: Oscilloscope window for file *sand120.dt4*. The color shown here may differ from the colors on your screen. However, the data shape of the signal should be identical. You can customize the colors your oscilloscope window by going to `Configuration` ▷ `Colors` .

Step 2 Preparing for analysis

Step 2a The group of numbers in the lower right-hand area of VBT™ corresponds to the location of the mouse cursor in the oscilloscope window.


Sample Number the cursor is on in the oscilloscope window
Depth the cursor is on in the oscilloscope window
Data Acquisition Pulse Duration
1:1/140
1224
-70.00
26.59m
120kHz
0.4ms
Channel Number: Active Ping /Total Number of Pings
(The same information is displayed in the heading of the oscilloscope window)
Intensity Value the cursor is on in the oscilloscope window.
Data Acquisition Sampling Frequency

Step 2b In the oscilloscope window, use the mouse to change the thresholds (horizontal lines). See Section 3.1 for more information on manipulating the oscilloscope window and Section 4.1 for more information on the bottom tracking parameters.

Step 2b-1 The lowest threshold, 'Data Processing Filter Threshold' should be greater than or equal to the 'Data Acquisition Threshold'.

Step 2b-2 The middle threshold, 'Bottom Detection Threshold' can be numerically defined by going to `Configuration` ▷ `Bottom Tracking Parameters`

Step 2b-3 The top threshold, 'Peak Threshold' can be numerically defined by going to `Configuration`

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▷ `Bottom Tracking Parameters` . The 'Peak Threshold' should be a few decibels below the highest peak in the data file.

Step 2c In the oscilloscope window, use the mouse to change the sampling windows (vertical lines). The sample windows should be adjusted so that the E1 sampling window (*the second half of the first bottom echo*) has red hatch marks in the oscilloscope window. See Section 3.1 for more information on manipulating the oscilloscope window.

> √ Note: Changes made to the sampling windows, sampling thresholds or within the method windows AFTER the data has been analyzed ('played') will not take effect until the data file is reanalyzed.

Step 2d There are 3 ways to select the bottom-typing method to analyze the data with:

Bottom-Typing

i Press the corresponding method button in the toolbar

– or –

ii Select the the corresponding method from `Select Bottom Typing Method` in the `CONFIGURATION MENU`

– or –

iii Select the the corresponding method from `Configure Bottom Typing Algorithms` in the `CONFIGURATION MENU`

We recommend always working with Method B4. Please refer to Section 3.2 and Section 2.1.2 for in-depth information on manipulating the method windows.

> √ Note: Only one bottom classification method can function at a time. The data will be classified according to the last open method window or the method selected via `Configuration ▷ Select Bottom Typing Method.`

Step 2e Select the ground-truth data set to use for bottom-typing. If you have not yet created your own ground-truth data set, use the data set included with VBT™ (ID = 01 in the method window)

Step 3 Data Analysis - Bottom Tracking & Bottom-Typing

Play

Step 3a There are three ways to begin analysis of the data:

i Press the play button located in the toolbar

– or –

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ii Select `Play` from the ANALYZE MENU

– or –

iii Press 'F5'.

Step 3b When analysis begins, an echogram window and output reports window appear on the screen:

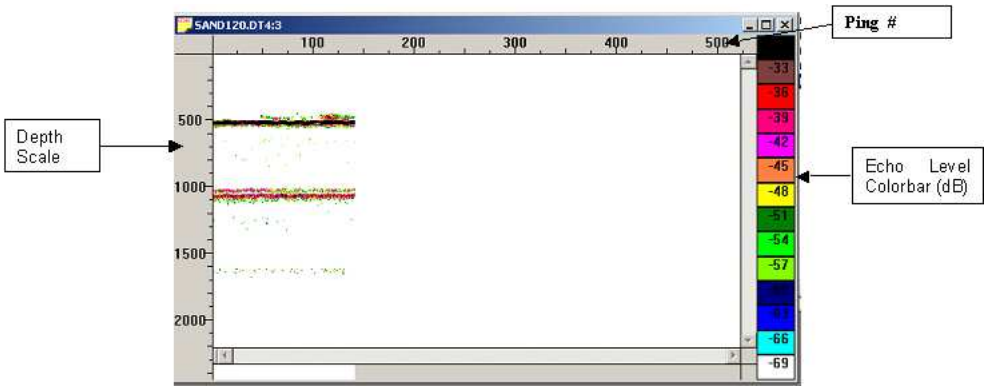
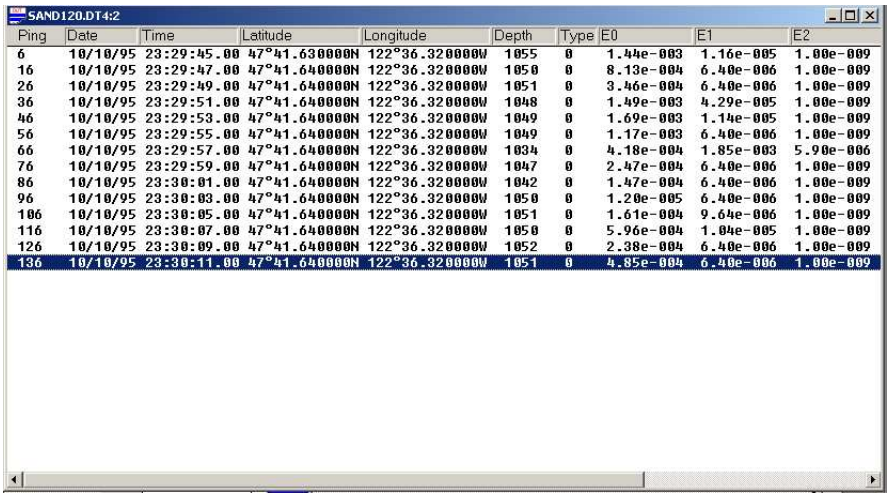


Figure 1.7: Echogram window for file *sand120.dt4*. (See Section 3.3 for more information on interpreting echogram windows).


SAND120.DT4:2

Ping	Date	Time	Latitude	Longitude	Depth	Type	E0	E1	E2
6	10/10/95	23:29:45.00	47°41.630000N	122°36.320000W	1055	0	1.44e-003	1.16e-005	1.00e-009
16	10/10/95	23:29:47.00	47°41.640000N	122°36.320000W	1050	0	8.13e-004	6.40e-006	1.00e-009
26	10/10/95	23:29:49.00	47°41.640000N	122°36.320000W	1051	0	3.46e-004	6.40e-006	1.00e-009
36	10/10/95	23:29:51.00	47°41.640000N	122°36.320000W	1048	0	1.49e-003	4.29e-005	1.00e-009
46	10/10/95	23:29:53.00	47°41.640000N	122°36.320000W	1049	0	1.69e-003	1.14e-005	1.00e-009
56	10/10/95	23:29:55.00	47°41.640000N	122°36.320000W	1049	0	1.17e-003	6.40e-006	1.00e-009
66	10/10/95	23:29:57.00	47°41.640000N	122°36.320000W	1034	0	4.18e-004	1.85e-003	5.90e-006
76	10/10/95	23:29:59.00	47°41.640000N	122°36.320000W	1047	0	2.47e-004	6.40e-006	1.00e-009
86	10/10/95	23:30:01.00	47°41.640000N	122°36.320000W	1042	0	1.47e-004	6.40e-006	1.00e-009
96	10/10/95	23:30:03.00	47°41.640000N	122°36.320000W	1050	0	1.20e-005	6.40e-006	1.00e-009
106	10/10/95	23:30:05.00	47°41.640000N	122°36.320000W	1051	0	1.61e-004	9.64e-006	1.00e-009
116	10/10/95	23:30:07.00	47°41.640000N	122°36.320000W	1050	0	5.96e-004	1.04e-005	1.00e-009
126	10/10/95	23:30:09.00	47°41.640000N	122°36.320000W	1052	0	2.38e-004	6.40e-006	1.00e-009
136	10/10/95	23:30:11.00	47°41.640000N	122°36.320000W	1051	0	4.85e-004	6.40e-006	1.00e-009

Figure 1.8: Report Window for file *sand120.dt4*. You can choose to exclude/include data fields by going to `Configuration` ▷ `Output Report Export Field` . You can alter the date and direction format by going to `Configuration` ▷ `Output Report Format Options` .

Step 4 Interpreting the Bottom-Typing Results

Step 4a Echogram window - during analysis the color-code (See Section 3.3) of the bottom-type for each ping will appear along the bottom axis

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Step 4b Output report window - during analysis the numerical-code (See Section 3.4) of the bottom-type for each ping will appear in the 'Type' column

Step 4c Map window - during analysis, if the map window is open, the color-code of the bottom-type for each ping will appear at the corresponding coordinates in the map window

Step 5 Export the Bottom-Typing Results
See Section 1.7.4 for information on exporting the bottom-typing results.

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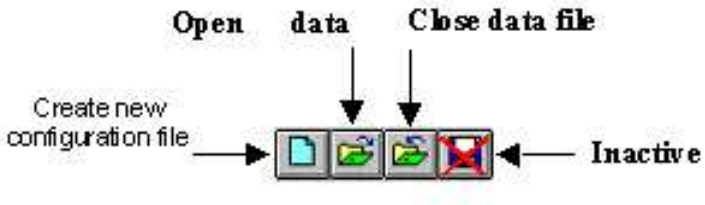
1.6 VBT™ Toolbar

1.6.1 File Buttons



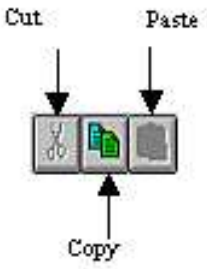
Create New Configuration File- resets to factory settings

Open Data File- allows user to browse directory in order to select data file

Close Data File- closes data data file and all associated windows

Save- inactive. use the export data commands in the menubar

1.6.2 Edit Buttons



Cut- inactive

Copy- allows you to copy objects to the clipboard for pasting the object in other programs

Paste- allows you to paste a bitmap image from the clipboard into the Map Window

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1.6.3 Zoom Buttons

Zoom-in and zoom-out can be used with the oscilloscope and echogram windows. In addition to the toolbar buttons, you may zoom into either window by drawing a box using left mouse button. The zoomed-in view for the echogram window will appear in a new window. Double-clicking in the window will return the window to its original view.

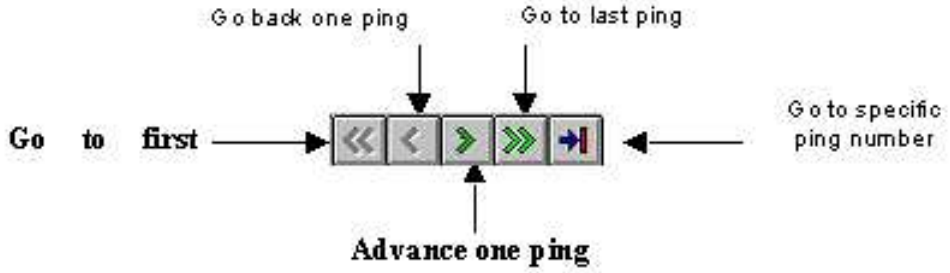
1.6.4 Play Buttons

Play- begins data analysis of the data from the beginning of the data file

Stop- pauses further analysis of the data

Ping Navigation Buttons

A ping refers to the data obtained from a single pulse sent out by the echosounder. A data file consists of hundreds, sometimes thousands of pings. When the oscilloscope window or any of the method windows is activate, the ping navigation portion of the toolbar is also activate.



Use the ping navigation button to move through the pings in the data file in the oscilloscope window or method windows. Double-clicking on a ping in the echogram window, will bring that ping up in the oscilloscope window.

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√ Note: If you wish to analyze a file more than once (i.e. to see the results of changes made through the CONFIGURATION MENU), select the 'go to first ping' button and press 'play' again. New echogram and output report windows will appear during the reanalysis.

1.6.5 Bottom Typing Method Buttons

The bottom-typing method buttons allow you to select which signal analysis method to use (See Chapter 4.2 for a brief description of each method).

Only one bottom classification method can function at a time. The data will be classified according to the last open method window or the default method (B4). The method in use is highlighted with a red rectangle. In-depth tutorials for each bottom classification method are included in Chapter 2.

Tip: the oscilloscope window must be active for the bottom typing buttons to be active.

B1- First Echo Normalization (cumulative curves)

B2- First /Second Bottom Ratio

B3- First Echo Division

B4- Fractal Dimension

S- Sediment (layer above the bottom)

1.6.6 Print & Help Buttons

Print- prints active window

Help- opens help file

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1.7 Menubar Commands

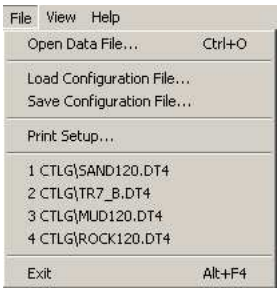
1.7.1 File Menu

After launching the program, you can either open a data file or load a previously saved configuration file. If you open a data file, the default configuration file (c:\windows\VBT.INI) will be used.

√ Note: The default configuration file will be updated *after* VBT™ (or a data file) is closed. We recommend backing-up VBT.ini (found in C:\Windows) before beginning to use VBT. This will allow you to restore the default settings in the future.

Before a data file is open

Before a data file is open, you have the option to:



Load Configuration File - choose this option, if you wish to use a Configuration file saved previously . The settings saved in the previously saved Configuration file will be applied during this session.

Save Configuration File[4]**-**

Open a Data File- allows you to browse through your directory to select a data file

If you do not need to load or save a Configuration file, simply open a data file.

√ Note: Once you option a data file, you do not have the option to change the Configuration file.

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After a data file is open

When a data file is open, you can:

Open a Data File- allows you to browse through your directory to select a data file

Close a Data File- closes the open data file and all associated windows

Export The Ping Data To A File- allows you to export pings to a file in either ASCII format or in BioSonics, Inc. DT4 format. In ASCII format, each line of the text file is a single ping and each number contained in the line is a sample. (Refer to Section 1.7.4 for more information on this command).

Print- allows you to print the active Oscilloscope window.

Recent File List- allows you to select from the last four data files opened in software

1.7.2 View Menu

As described in the following subsections, the VIEW MENU allows you to:

1. customize the oscilloscope window
2. customize the echogram window
3. navigate through the pings in the data file
4. zoom in the oscilloscope, echogram or map windows
5. show the map window

View ▷ Oscilloscope

In the Oscilloscope submenu, you may select whether or not to display the following objects in the Oscilloscope window:

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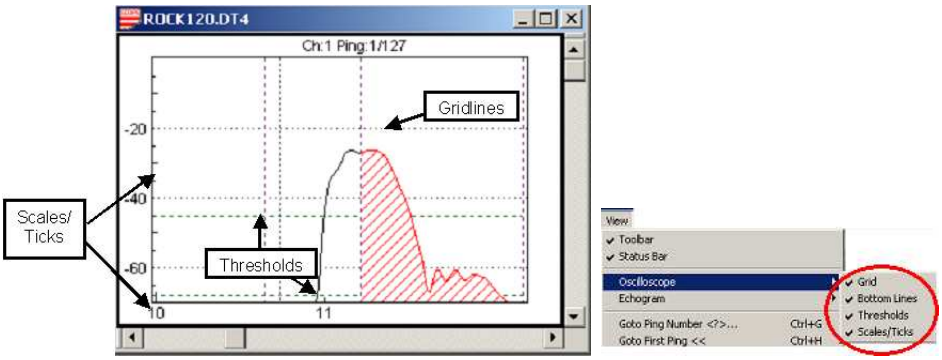


Grid - displays gridlines in the oscilloscope window

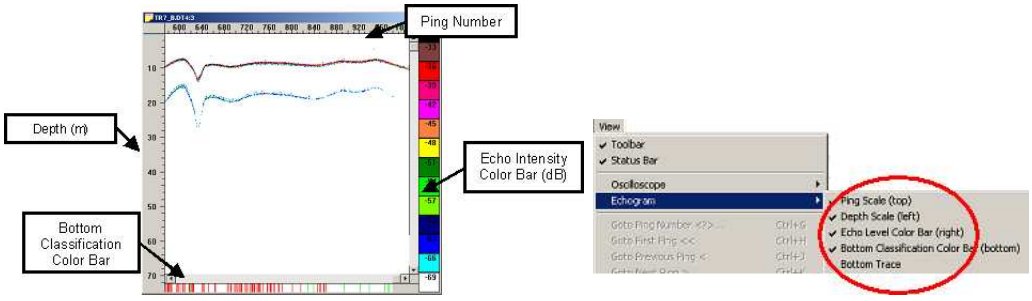
Thresholds - displays a dotted horizontal line for the Bottom Detection Threshold and the Peak Threshold (defined in `Configuration ▷ Bottom Tracking Parameters`).

Bottom Lines - sampling windows for bottom tracking (defined in `Configuration ▷ Bottom Tracking Parameters`)

Scales/Ticks - display axes labels and tick marks in the oscilloscope window

View ▷ Echogram

The echogram submenu allows you to select or deselect the axes to view.



Ping Scale - ping number is the horizontal axis in the echogram window

Depth Scale - the depth of each sample in each ping is plotted vertically

Echo Level Color Bar - the relationship between the color of each sample and its energy intensity

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Bottom Classification Color Bar the color code of the bottom-type for each ping

Bottom Trace draws a vertical line indicating the presence of a lost bottom signal (see Chapter 4.1)

View ▷ Navigate Pings

This section of the VIEW MENU contains commands which allow you to move through the pings contained in the data file using the oscilloscope window.

Go to Ping Number - allows you to specify a ping to view

Go to First Ping - brings the Oscilloscope window to the first ping. Use this command to reanalyze a data file after you have made any changes to the settings

Go to Previous Ping - allows you to view the previous ping in the Oscilloscope window

Go to Next Ping - allows you to view the next ping in the Oscilloscope window

View ▷ Zoom

Zoom In - allows you to zoom-in (in the echogram, Oscilloscope or map windows only)

Zoom Out - allows you to zoom-out (in the echogram, Oscilloscope or map windows only)

View ▷ Show Map Window

The `Show Map Window` command displays the map window associated with the open data file. To associate a map image file with a data file, use either `Import Map Image from File` or `Paste Map Image from File` from the EDIT MAP MENU and select the map image you wish to use. Once a picture file is associated with the data file, it can always be opened using the `Show Map Window` command.

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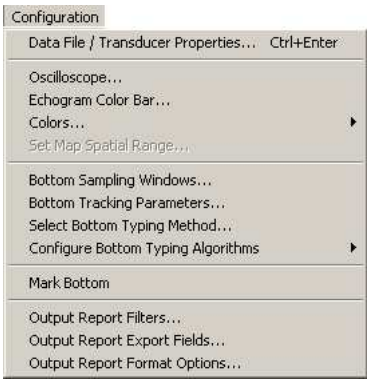
1.7.3 Configuration Menu

The CONFIGURATION drop down menu allows the user to view and/or change the default analysis settings, e.g. filter threshold or the number of pings per report. When changes to the default settings are made BEFORE the data file is 'played', the changes will be implemented to the active file and any future data file. If the changes are made AFTER the file has been 'played', the changes will be implemented when the file is replayed or when the original file is closed and any subsequent data file is opened .



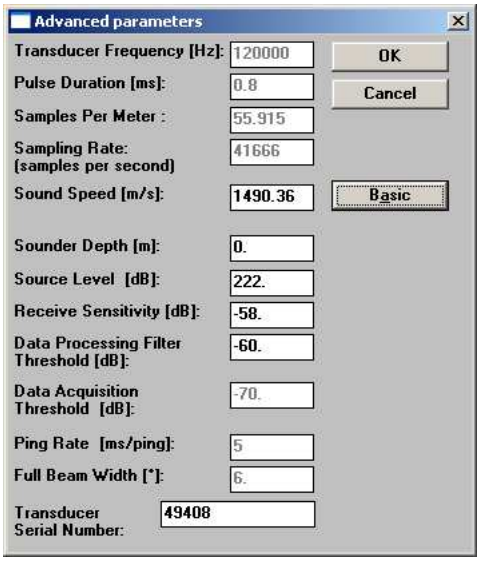
Go to 1st ping

Configuration ▷ Data File/ Transducer Properties

To view the transducer and data file properties go to `Configuration ▷ Data File/ Transducer Properties`. Select 'Advanced Properties' to view all data acquisition parameters. You may only vary the following parameters:

- sound speed
- Data processing filter threshold

Use the 'Data processing filter threshold' to reduce the effect of noise in the signal present near the 'Data acquisition threshold'. The remaining fields describe the parameters during data acquisition and therefore cannot be changed.



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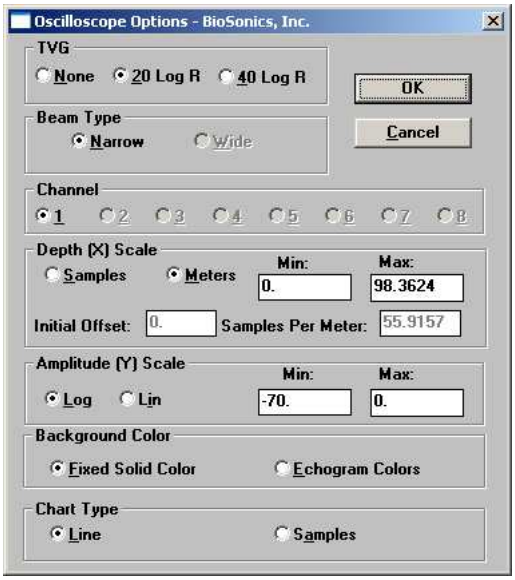
Configuration ▷ Oscilloscope



You can change the display format of the oscilloscope window by selecting `Oscilloscope` in the CONFIGURATION MENU (when the Oscilloscope window is active) or by right-clicking in the oscilloscope window. The default settings are shown in the following figure.

TVG (Time Varied Gain) - The decibel scale can be set to either: None, 20logR (default) or 40log R

√ Note: 20logR is the proper setting for the theoretical model of a non-point source reflector

Beam Type - [5]

Channel - used for multiplex data files (where the DT-X system used more than one transducer) to specify which channel to analyze.

√ Note: Only one channel can be analyzed at a time.

Depth (X) Scale - You may view the bottom depth in units of digital samples or meters
- You may manually set the range of the horizontal axis by entering values in the 'Min.' and 'Max.' fields

Amplitude Scale - You may view the intensity of the signal on a logarithmic or linear scale
- You may customize the range of the vertical axis by entering values in the 'Min.' and 'Max.' fields

Background Color -

[5] This function does not work properly for this release of VBT™ .

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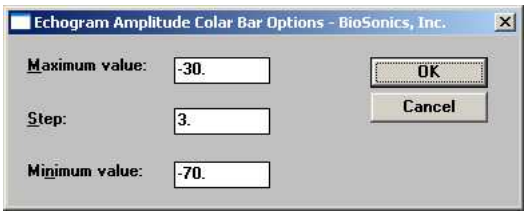
fixed solid color - sets the background of the Oscilloscope window to the color defined in `Configuration ▷ Colors ▷ Scope` .

Echogram Colors - sets the background of the Oscilloscope window to coincide with the Echogram intensity colorbar defined in `Configuration ▷ Echogram Color Bar` along the intensity axis (vertical axis)

Chart Type - [6]

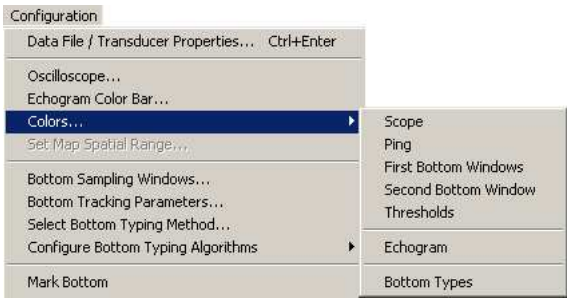
(See Section 3.1 for additional information on working with the Oscilloscope window).

Configuration ▷ Echogram Color Bar



To change the scale or range of the echogram color bar, select `Echogram color bar` in the CONFIGURATION MENU (when the Oscilloscope window is active). The pop-up window allows you to change the minimum, maximum and step value (in decibel units) displayed on the colorbar (on the right hand side) of the Echogram window. Each step is assigned a new color from the color table defined in `Configuration ▷ Colors ▷ Echogram` .

Configuration ▷ Colors



Selecting `Colors` in the CONFIGURATION MENU, brings up a submenu. The first five options (`Scope` , `Ping` , `First Bottom Windows` , `Second Bottom Window` , and `Thresholds`) allow the user to change Colors associated with the Oscilloscope window.

[6] This function does not work properly for this release of VBT™ .

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Scope allows you to select the background color for the oscilloscope window

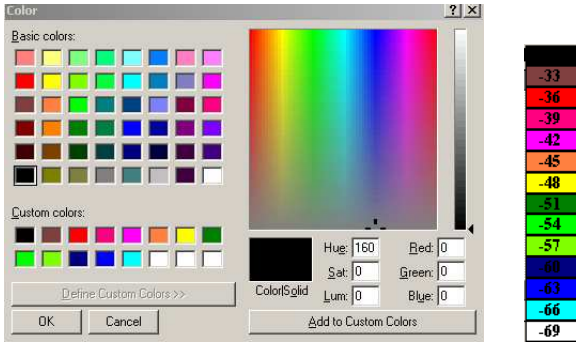
Ping allows you to select the color of the signal plot in the oscilloscope window

First Bottom Windows allows you to select the color of the sampling windows (vertical lines) for the first bottom echo (E1 and E1′)

Second Bottom Window allows you to select the color of the sampling window (vertical lines) for the second bottom echo (E2)

Thresholds allows you to select the color of the bottom tracking thresholds (peak threshold, bottom detection threshold and data analysis threshold)

Echogram allows you to customize the echo intensity color bar (right-hand side of the echogram window). Each color can be manually selected by first choosing a color (in either 'Basic Color' or the color chart) and then selecting 'Add to Custom Colors'. The colorbar colors will be displayed in the order of the colors in the 'Custom Color' section.



Bottom Types allows you to customize the color code for each bottom type (for the echogram window and the method windows). Each color can be manually selected by first choosing a color (in either 'Basic Color' or the color chart) and then selecting 'Add to Custom Colors'. The color code for each bottom type is determined by the order in which the ground-truth data file was opened, where the first color in the 'Custom Color' section corresponds to the first file opened. (see 2.1.2).

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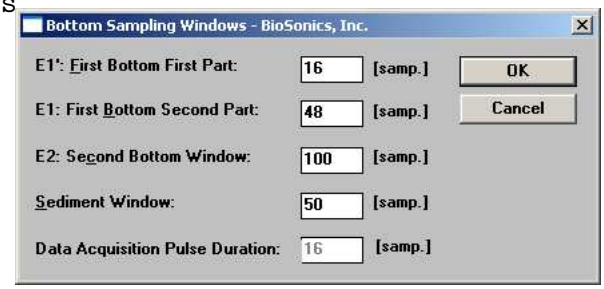
Configuration ▷ Bottom Sampling Windows

The `Bottom Sampling Windows` menu items allow the user to specify the widths of sampling windows for the following events: first bottom first part (E1′), first bottom second part (E1), second bottom window (E2), and sediment window (S). The 'Data acquisition pulse duration' is provided for reference and cannot be altered.
.



Tip: E2 is only necessary when using Method B2

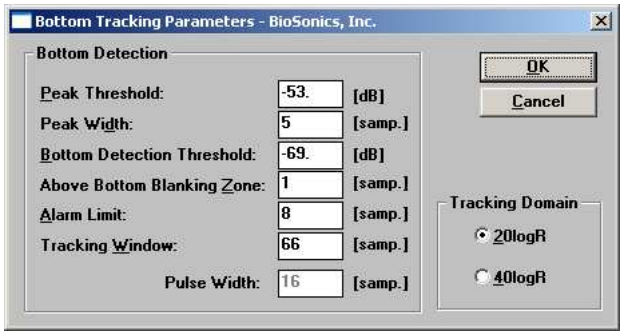
We recommend using the following values (See Chapter 4.1 for more information on bottom tracking):

Table 1.3: Recommended Bottom Sampling Window Widths

Sampling Window	Methods B2, B3 & B4	Method B1
E1	3 × pulse duration	0[7]
E2	6 × pulse duration	6 × pulse duration
S	50 samples	50 samples

Configuration ▷ Bottom Tracking Parameters

The `Bottom Tracking Parameters` Window allows the user to improve the accuracy of the bottom detection algorithm by manually specifying the parameters described in the following table. Please refer to Chapter 4.1 for detailed information regarding the bottom tracking parameters.



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Bottom Tracking Parameters

Peak Threshold The minimum intensity an echo must reach (for PEAK WIDTH number of samples) to be considered a bottom echo

Peak Width The minimum number of consecutive samples an echo must be above the PEAK THRESHOLD to be considered a bottom echo

Bottom Detection Threshold The maximum intensity a portion of the echo must fall below (ABOVE BOTTOM BLANKING ZONE number of samples) to be considered an endpoint of the bottom echo

Above Bottom Blanking Zone The minimum number of consecutive samples an echo must be below the BOTTOM DETECTION THRESHOLD to be considered a bottom echo

Alarm Limit The number of consecutive lost bottoms before the bottom tracking algorithm is reinitialized and the bottom echo is tracked from the bottom of the last ping's bottom echo

Bottom Tracking Window Search window for the bottom-tracking algorithm. The window is centered on the bottom line of the last found bottom and the algorithm searches for the next bottom within the window in both directions.

Lost Bottom When a bottom echo is not found within the 'bottom tracking window' it is referred to as a 'lost bottom'

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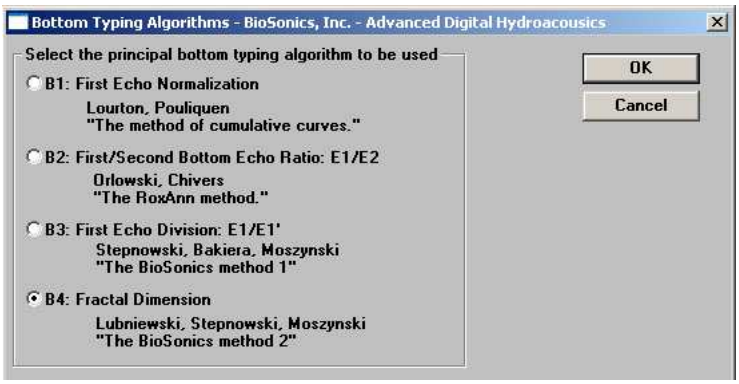
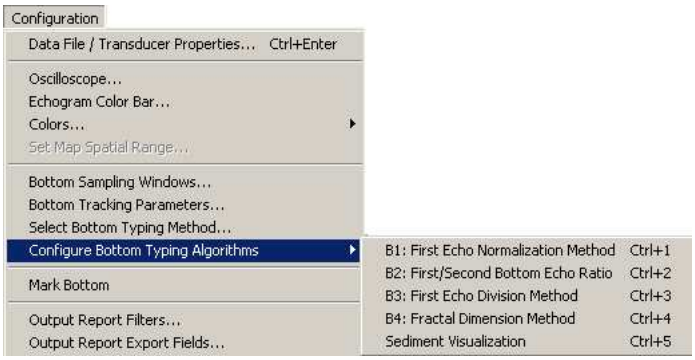
Configuration ▷ Select Bottom Typing Method

To change the bottom-typing method used to classify your data set, choose `Select Bottom Typing Method` from the CONFIGURATION MENU. (This is the same as selecting the bottom-typing method in the toolbar.) Method B4 is the default (and recommended) bottom-typing algorithm for use with VBT™ and will be implemented automatically when you do not select an alternative bottom-typing method.


Bottom Typing Algorithms - BioSonics, Inc. - Advanced Digital Hydroacousics
Select the principal bottom typing algorithm to be used
B1: First Echo Normalization
Lourton, Pouliquen
"The method of cumulative curves."
B2: First/Second Bottom Echo Ratio: E1/E2
Orlowski, Chivers
"The RoxAnn method."
B3: First Echo Division: E1/E1'
Stepnowski, Bakiera, Moszynski
"The BioSonics method 1"
B4: Fractal Dimension
Lubniewski, Stepnowski, Moszynski
"The BioSonics method 2"
OK
Cancel

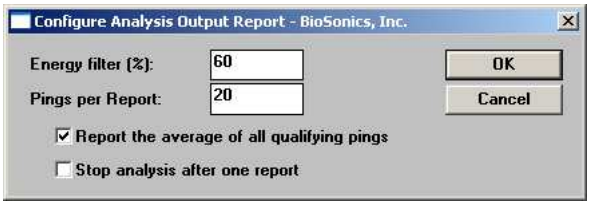
Configuration ▷ Configure Bottom Typing Algorithms

You may open up the method window for any bottom-typing algorithm by highlighting `Configure Bottom Typing Algorithm` and the appropriate method window. The bottom-typing method in use by the algorithm is highlighted with a red rectangle.



Configuration ▷ Output Report Filters

In the Configuration menu, 'Output Report Filters' allows you to select: the energy filter and the number of pings per re-



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port. Each line in the Output Report Window is one 'report'. The value entered in the energy filter specifies the lowest amount of energy a ping can have to be included in the analysis. The energy filter is in terms of the percent of the maximum energy present in the data file and can be described using the following mathematical approximations.

$$EP_i = \int (P_i) dx$$

where EP_i is the energy of the i^{th} ping
and P_i is the ping plotted against depth (x).

EP is calculated for all pings in the data file and the highest value of EP (called EP_{max}) is determined. The energy of each ping is compared to EP_{max} using the ENERGY FILTER:

an output report line is created for all
$EP_i \geq x \cdot EP_{max}$ where x = ENERGY FILTER

For example, the energy filter shown in the figure to the left allows samples with a value of 60% or more EP_{max} to pass and be analyzed by the VBT algorithm.

The 'Pings per Report' option allows you to specify the step size between pings displayed in the output report window, as well any exported report file. When the option 'Report the average of all qualifying pings' is selected, the algorithm returns the average all pings that pass through the filters in a ping step. For example, the output for ping 31 (when pings per report is 20) is the average of all values over 60% for pings 12-31. When the averaging option is not selected, all pings that pass through the filter are displayed.

The option 'Stop analysis after 1 report' stops the analysis after 1 report. If 'report the average of all qualifying pings' is selected, the analysis will stop after 1 ping report and the output report window will show 1 report containing the average of all 'Pings per Report' pings that exceed the energy filter. If the averaging option is not selected, all pings that exceed the Energy filter are reported, for each grouping of 'Pings per Report'. In either scenario, the next report is generated by pressing the play button. This option is extremely useful when customizing feature space using the method windows.

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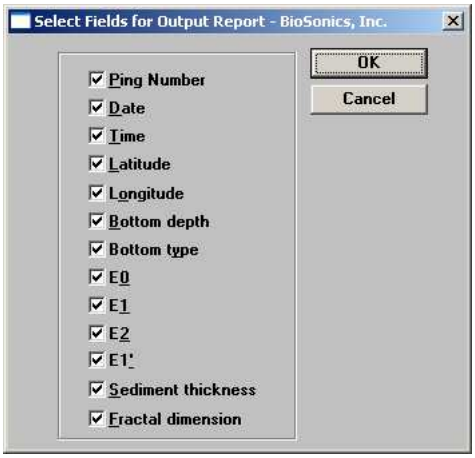
Pings per Report 'N' number of pings to be included in one report in the output report window. If 'averaging' is selected, the report will show the average of each set of 'N' pings that surpass the energy filter. If averaging is not selected, all pings that exceed the ENERGY FILTER will be reported (independent of the value of N)

Energy Filter The minimum energy a ping must have to be reported, calculated as a percentage of the maximum energy present in the data file.

Configuration ▷ Output Report Export Fields

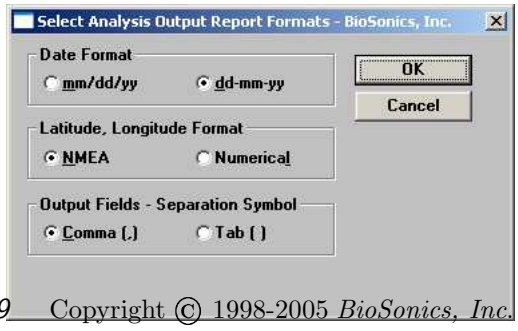
You can specify the fields to include in the Output Report window (and any related export files) by going to `Configuration ▷ Output Report Export Fields` .



Configuration ▷ Output Report Format Options.

The `Output Report Format Options` command in the CONFIGURATION MENU allows you to select the format for the date, longitude & latitude, and output file delimiter.

Date Format allows you to specify a date format of: mm/dd/yy or dd-mm-yy



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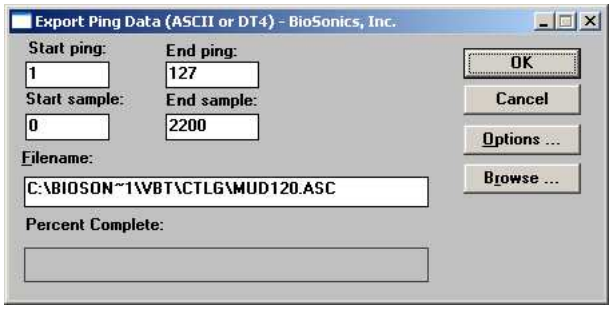
Latitude,Longitude Format allows you to specify a latitude,longitude in NMEA format or numerical format. (See Section 1.7.5 for a description of NMEA and numerical formats)

Output Fields - Separation Symbol allows you to specify the delimiter between output report columns (comma separated value or tab separated value[8])

√ Note: Specifications made in `Configuration ▷ Output Report Export Fields` and `Output Report Format Options` will affect both the Output Report window and any exported report file.

1.7.4 Export Data Menu

Export Data ▷ Export Pings to File



The raw data (digital samples) contained in an open *.dt4 file can be exported as a text file using this command. Each line of the resulting text file is a single ping and each number contained in the line is a sample.

√ Note: The 'Data Acquisition Threshold' (found in `Configuration ▷ Data File/ Transducer Properties`) is displayed for any sample whose intensity is less than or equal to the 'data acquisition threshold'.

[8]This function does not work properly for this release of VBT™ .

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Start Ping allows you to specify the first ping to include in the data file

End Ping allows you to specify the last ping to include in the data file. The last ping is displayed by default

Start Sample allows you to specify the first sample to include in the data file

End Sample allows you to specify the last sample to include in the data file

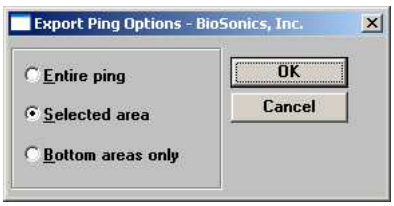
√ Note: Specifying a sample range here will export the same range for all pings. Export all samples to avoid losing part of your data file.

Filename allows you to specify the path for the output file

Percent Complete displays the status of the exportation

OK select 'OK' to export the pings to file

Cancel select 'Cancel' in order to cancel the export



Options allows you to export the following by highlighting them with your mouse:

a specific ping

a specific sample range of the displayed ping

bottom areas only

Browse allows you to specify the path for the output file

√ Note: Make sure 'Stop Analysis After 1 Report' (in `Configuration ▷ Output Report Filters`) is deselected. Otherwise, you will need to select 'okay' after each report in order to export the entire data file.

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Table 1.4: Import/Export File Formats

Object	*File Format*	*Description*
Echogram	*.bmp	Bitmap, can be imported into most word processing programs
Report	*.csv	Comma separated values, can be tabulated into a spreadsheet
Map	*.bmp	Bitmap, can be imported into most word processing programs
DT4 raw data	*.txt	text file

Export Data ▷ Copy Object to Clipboard

The command `Copy Object to Clipboard` (found in the **EXPORT/DATA MENU**), places an image of the active window into the clipboard. The image can then be pasted into another program, such as a text editor. This function is only available for the Echogram window, the report window or the map window.

√ Note: if the window has been zoomed into, only the zoomed in portion of the window will be copied. Zoom-out to copy the entire window.

Export Data ▷ Export Object to File

The `Export Object to Clipboard` command, saves the active window to a user-specified file. This function is only available for the Echogram window, the output report window or the map window. The window-type and its corresponding file format are listed in the Table 1.7.4.

√ Note: if the window has been zoomed into, only the zoomed in portion of the window will be copied. Zoom-out to copy the entire window.

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1.7.5 Edit Map Menu

Edit Map ▷ Show Map Window

The `Show Map Window` command allows you to associate a map image with the open data file. A map image file is associated with a data file, when the map picture file is opened while the data file is open by using either `Import Map Image from File` or `Paste Map Image from Clipboard` from the EDIT MAP MENU.

Once a picture file is associated with the data file, it can always be opened using the `Show Map Window` command

Edit Map ▷ Import Map Image from File

In order to import a map image from a file, the `Show Map Window` command must first be selected. VBT™ supports map images of the following formats: bitmap (*.bmp), Windows Metafile (*.wmp) and Graphic Interchange Format (*.gif).

> √ Note: VBT™ is indiscriminate with respect to map files. If you import any supported graphics file VBT will assume the file is a map of appropriate coordinates and plot the results accordingly.

Edit Map ▷ Paste Map Image from Clipboard

Paste

In order to paste a map image from a file, the `Show Map Window` command must first be selected. VBT supports map images of the following formats: bitmap (*.bmp), Windows Metafile (*.wmp) and Graphic Interchange Format (*.gif). If a supported image file is in the clipboard, you may paste it into an active map window using this command. This can also be achieved by selecting the paste button in the toolbar.

> √ Note: VBT is indiscriminate with respect to map files. If you import any supported graphics file VBT will assume the file is a map of appropriate coordinates and plot the results accordingly.

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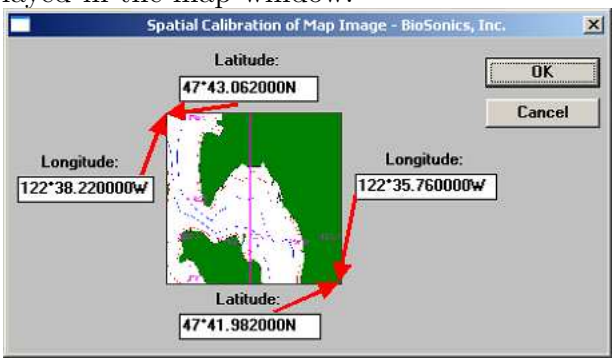
Edit Map ▷ Calibrate Map Spatial Range

When a map window is active, you may specify the coordinates of the map file using this command window. You must specify the coordinates of any map file that was not generated by BioSonics, Inc. . Otherwise, the bottom-types will not be displayed in the map window.



The spatial range of the map is established by entering the latitude and longitude of the top-left and lower-right hand corners of the map image in degrees-decimal minutes. Decimal minutes are converted to minutes-seconds by multiplying by 60. For example, $122^o38.2200W$ converts to degrees-minutes-seconds by multiplying .22 by 60, which results in $122^o38'13.2W$. Decimal minutes are converted to decimal-degrees by dividing the minutes by 60. For example, $122^o38.2200W$ converts to degrees-decimal minutes by dividing 38.22 by 60, which results in -122.637^o.

1.7.6 Analyze Menu

Play

You may begin analysis of the data by (1) selecting `Play` in the **ANALYZE MENU**, (2) hitting the play button in the toolbar or (3) pressing 'F5' on your keyboard.

If 'Stop analysis after 1 report' has been selected (via `Configuration ▷ Output Report Properties`), you may continue analysis by pressing play until you reach the end of the data file.

Go to 1st Ping

If you make changes via the **CONFIGURATION MENU** after analyzing the data, you can re-analyze the data by selecting the go to first ping button in the toolbar and hitting play again (new Echogram and Output Report windows will open).

Stop

Pressing in stop the toolbar, 'F10' on your keyboard or selecting 'Stop' from the **ANALYZE MENU** will stop analysis of the data.

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1.7.7 Window Menu

Duplicate Windows - creates a copy of all open windows and allows you to reanalyze the data.

Cascade - cascades all open windows

Tile - tiles all open windows

1.7.8 Help Menu

The help command allows you to bring up an electronic copy of the user's guide.

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Chapter 2

Tutorials

As described in Section 1.5, there are five major steps for analyzing a data file using VBT™ : loading the data file, preparing the data file for analysis, analyzing the data file, interpreting the analysis results and exporting the bottom-typing results. Before a data file can be analyzed a ground-truth library must be created by the user. This section describes (1) how to create a ground-truth library and (2) how to analyze the data file using the ground-truth library.

BioSonics, Inc. VBT™ - SeaBed Classifier includes five methods of bottom-typing:

B1- First Echo Normalization (cumulative curves)

B2- First /Second Bottom Ratio

B3- First Echo Division

B4- Fractal Dimension

S- Sediment (layer above the bottom)

√ Note: Although all method windows can be displayed at the same time, the algorithm will perform classification of the bottom according to criteria of last open method window.

VBT™ also includes a practice library (found in the CTLG folder)with data files for various bottom-types (sand, rock, mud and soft mud). We recommend you familiarize yourself with the capabilities of VBT using the sample library before integrating your own data.

After you practice with the sample library, your own verified library can be integrated by first taking physical samples of the bottom and simultaneously recording the bottom echo signals. Once the data has been collected, you can create and save customized feature spaces for each bottom-types using the

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method windows. The customized feature space created from the physically-verified data sets is referred to as "ground-truth" library. The ground truth data is used to classify future data sets.

Verified standard databases for different types of the bottom should be stored in VBT™ using the bottom-typing method windows (B1, B2, B3, B4, S). Echo signal parameters depend not only of bottom type but also on data acquisition parameters (i.e. transducer frequency, beam width, pulse length etc.). Therefore the ground truth data set is valid for a particular set of equipment and for particular equipment parameters.

2.1 Ground-truth Library

The purpose of this tutorial is to illustrate (1) creating the ground-truth library and (2) classifying a transect according to the ground-truth library. There are two methods for creating a ground-truth library in VBT™ , (1) automatically generating the feature space boxes using the Fuzzy C-Means (FCM) clustering algorithm and (2) manually generating the feature space. Tutorial 2.1.1 demonstrates using the FCM algorithm and Tutorial 2.1.2 demonstrates manually generating the feature space. The results of both of the tutorials can be used in Tutorial 2.1.3 to classify your unknown data set.

The following tutorials use Method B4, but can also be applied to Methods B2 & B3.

√ Note: IT IS IMPORTANT TO FOLLOW THESE INSTRUCTIONS PRECISELY, PARTICULARLY THE ORDER OF TASKS.

2.1.1 Creating a Ground-truth library using Fuzzy C-Means (FCM) Clustering

VBT™ allows you to automatically generate feature space boxes for bottom-typing using the FCM Algorithm. Please see Section 3.2.3 for more information on working with the FCM Algorithm in VBT™ .

Step 1 Open data file *mud120.dt4*

Step 2 Activate method B4 by clicking on B4 in the toolbar or selecting

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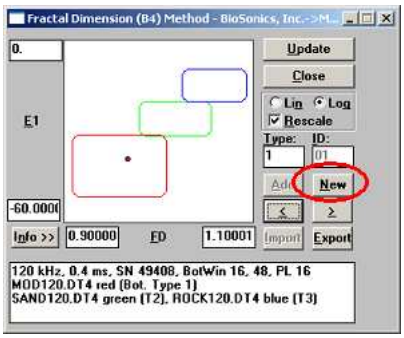
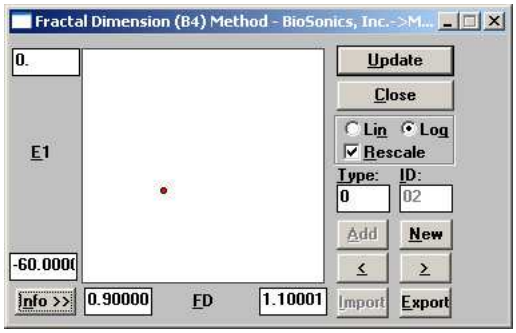
`Configure Bottom Typing Algorithms: B4` from the CONFIGURATION MENU

Step 3 In the method window, select the 'New' button to generate a new database. This will create a ground-truth data set:

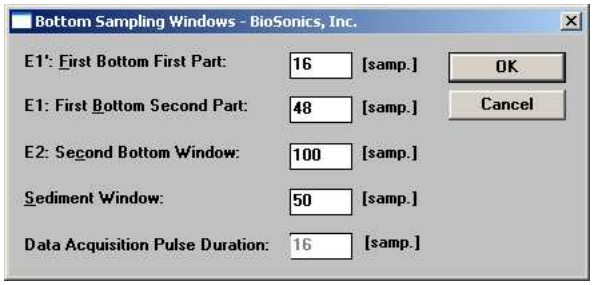




Step 4 Select `Bottom Sampling Windows` from the CONFIGURATION MENU. The data acquisition pulse is included in the window for reference and cannot be altered.)

Table 2.1: Recommended Bottom Sampling Window Widths

Sampling Window	Methods B2, B3 & B4	Method B1
E1	3 × pulse duration	0[1]
E2	6 × pulse duration	6 × pulse duration
S	50 samples	50 samples



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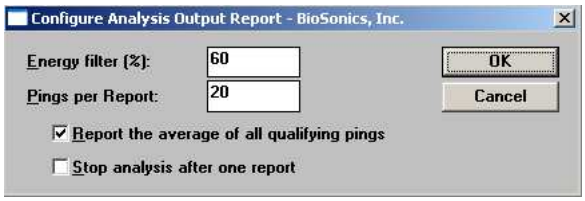
Step 5 Go to `Configuration ▷ Output Report Filters` . Deselect, 'stop analysis after one report' and leave all other parameters in their default settings.

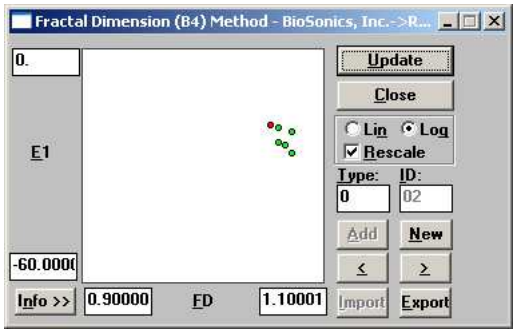


Step 6 Begin analysis of the data file by selecting 'play'.

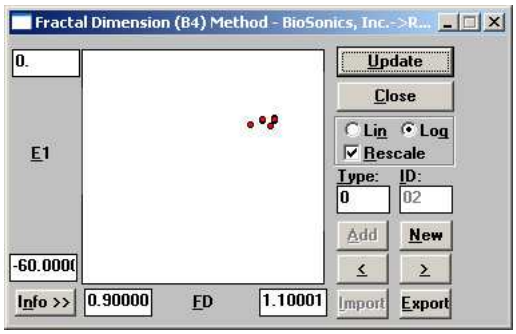
Step 7 Open *sand120.dt4*, verify 'stop analysis after one report' is deselected and analyze the data file.

Step 8 Open *rock120.dt4*, verify 'stop analysis after one report' is deselected and analyze the data file.

Step 9 Open the B4 Method Window



Step 10 Right-click on the method window titlebar and select 'Report View'. This will display only the pings for the rock data file that passed through the filter. All pings will be displayed in red.



Step 11 Right-click on the method window titlebar and select 'Multifile View'. This will display all pings that passed through the filter for all three

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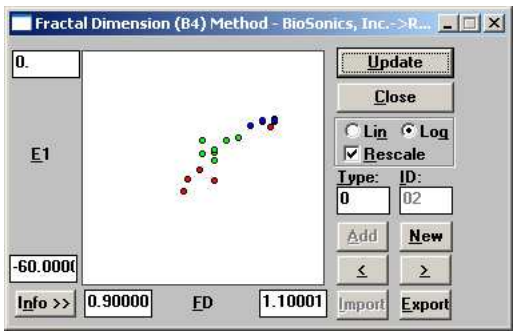
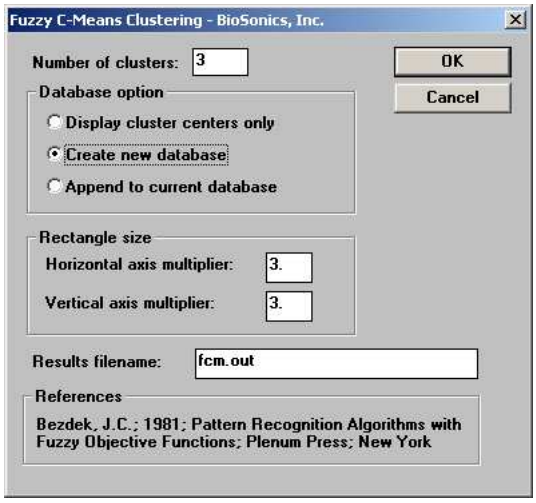
files. The pings for mud will be red, the pings for sand will be green and the pings for rock will be blue.



Step 12 Right-click on the titlebar and select 'FCM Algorithm'.



Step 12 - a Select 'Create new database' in order to add feature space boxes to the database you just created.

√ Note: When creating a ground-truth library, record (1) the order in which the feature spaces were created and (2) the data acquisition parameters in the "Info" section for future reference.

Step 12 - b Set the 'Number of Clusters' to 3. (The number of clusters should always be equal to the number of data files in use).

Step 12 - c Set the Rectangle Size multipliers to 3. The multiplier, expands the box size in multiples of the variance of each cluster set. The default value is one.

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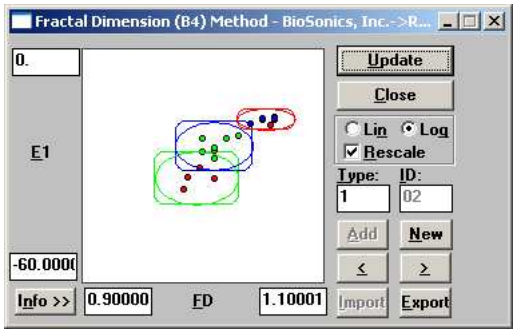
Step 13 Close the FCM Window. You should see a circle and a rectangle around each data clusters. The circle represents the space created by the FCM algorithm and cannot be altered. The rectangle is the feature space generated from each circle. The rectangles can be resized manually using your mouse.



Step 14 Hit 'Update' in the method window. 'Update' stores the database. The database will not be stored, if without selecting 'update'.

Step 15 Close the method window and follow the steps outlined in Tutorial 2.1.3, using the database you just created.

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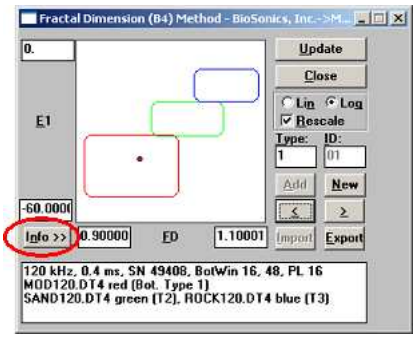
2.1.2 Manually generating a ground-truth library

Step 1 Open the sample library data file *mud120.dt4* (located in the CTLG folder).

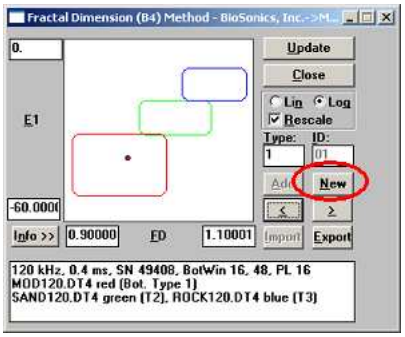
Step 2 Activate method B4 by clicking on B4 in the toolbar or selecting `Configure Bottom Typing Algorithms: B4` from the CONFIGURATION MENU.

Step 3 Select the "Info" button in method window. The "Info" windows contain information recorded by the user about this set of verified data files. You may edit the text directly.

√ Note: When creating a ground-truth library, record (1) the order in which the feature spaces were created and (2) the data acquisition parameters in the "Info" section for future reference.



Step 4 In the method window, select the 'New' button to generate a new database. The new database will be your ground-truth library.



Step 5 Activate the oscilloscope window (by clicking on it) and select `Bottom Sampling Windows` from the CONFIGURATION MENU and make sure the fields have the following values. (The data acquisition pulse is included in the window for reference and cannot be altered.)

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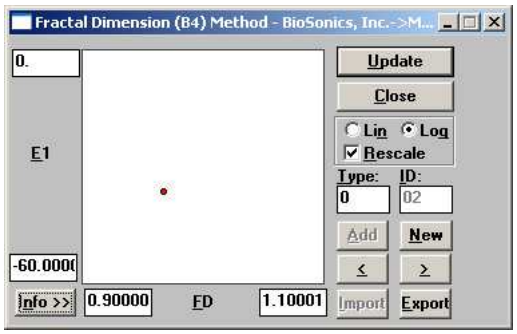
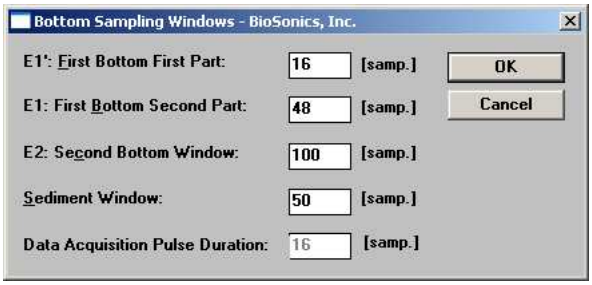
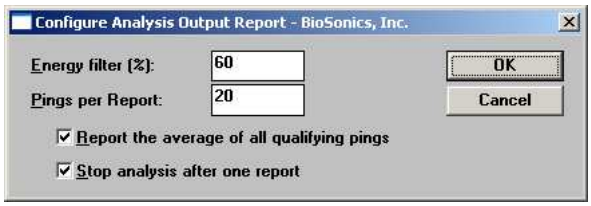


Table 2.2: Recommended Bottom Sampling Window Widths

Sampling Window	Methods B2, B3 & B4	Method B1
E1	3 × pulse duration	0^2
E2	6 × pulse duration	6 × pulse duration
S	50 samples	50 samples



Step 6 Go to `Configuration` ▷ `Output Report Filters` . Select, 'stop analysis after one report' and leave all other fields with their default values (as shown below).



Play

Step 7 Begin analysis of the data file by selecting the play button in the toolbar. After each report VBT™ pauses analysis and all pings will be displayed in B4 method window.

- **Red Dot-** Averaged value for all pings that pass through the filter
- **Blue Dot-** ping with more than 60 % of energy

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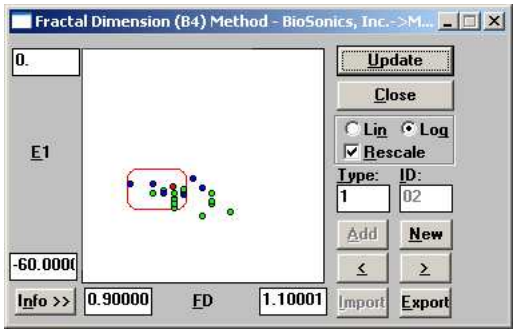
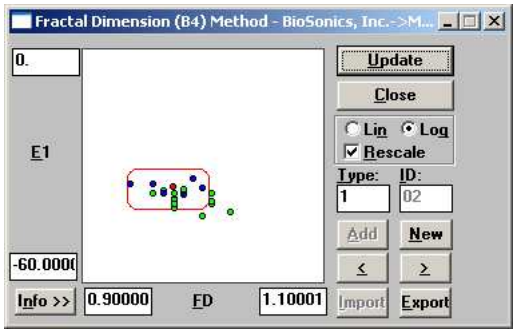
- **Green Dot-** ping with less than 60 % of energy

See Section 3.4 for an explanation of the energy filter.

Step 8 In the method window, draw a box around the blue dots (pings that exceed the energy filter) using the mouse. An example of the first report display is shown below.



Step 9 Adjust the feature space (red box) to tightly fit around all of the blue dots. Click 'Update'. This saves the settings to the catalog, so it can be used to classify unknown data sets in the future.



Step 10 Play the next ping data set and again adjust the feature space to encompass all of the blue dots. Be careful to adjust only the size of the box and not to move the box (or you may lose information from the last set of pings). Click 'Update' again.

Step 11 Repeat the cycle (analyze, adjust the box, and update the settings) until the entire data file as been processed.

Step 12 Right-click on the titlebar and select 'Report View'. This will show a cluster of red dots signifying the average value of all reports contained within the data file. Ensure the feature space encompasses all dots. Click 'Update'.

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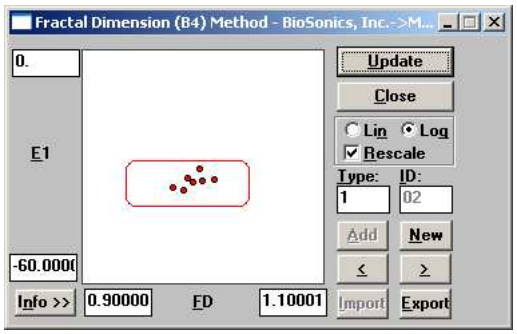


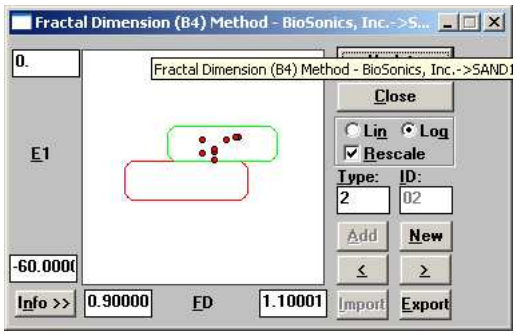
Step 13 Minimize all windows

Step 14 Open file *sand120.dt4* and repeat Steps 6 - 13.

Tip: Be sure to select 'stop analysis after one report'

√ Note: In the method window, the box will be green. The color of the box is determined by the order in which the box was drawn. The significance of the color of the dots does not change in Report View.

Step 15 Right-click on the titlebar in the method window and select 'Report View'. In 'Report View' the method window, should look similar to the following figure.



Step 16 Right-click on the titlebar in the method window and select 'Multifile View'. 'Multifile View' shows the average dots for each open file. The color of the dots corresponds to the color of the feature space box, e.g. red for mud and green for sand.

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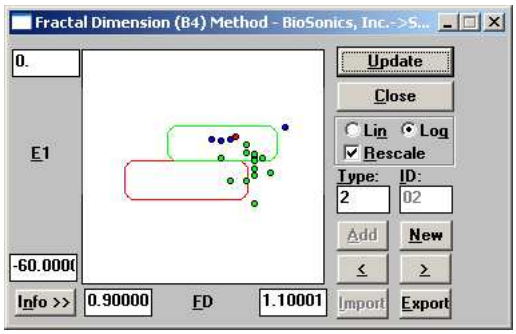


Step 17 Minimize all windows.

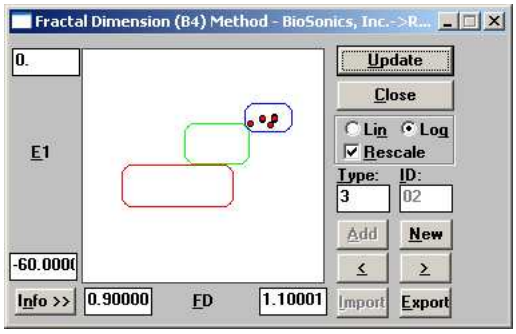
Step 18 Open file *rock120.dt4* and repeat Steps 6 - 13.

√ Note: The feature space box will be blue for the third file, *rock120.dt4*.

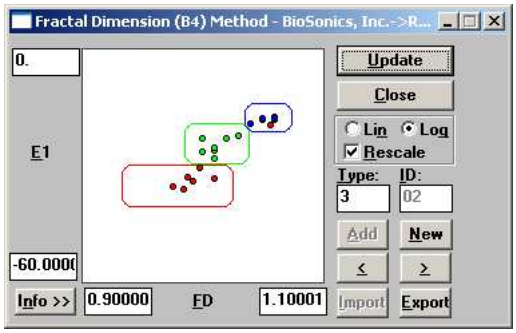
Tip: Be sure to press the Update button throughout analysis.

Step 19 In 'Report View' the feature space should look as follows:

√ Note: the sand feature space (green box) was adjusted to avoid overlap with the rock feature space (blue box).



Step 20 In 'Multifile View' the feature space should look as follows:



Step 21 Minimize all windows. You have successfully created a ground-truth library. Proceed to the next section to learn how to analyze a data file using your ground-truth library.

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2.1.3 Classifying data using your ground-truth library

Step 1 Open file: *TR7_B.dt4*

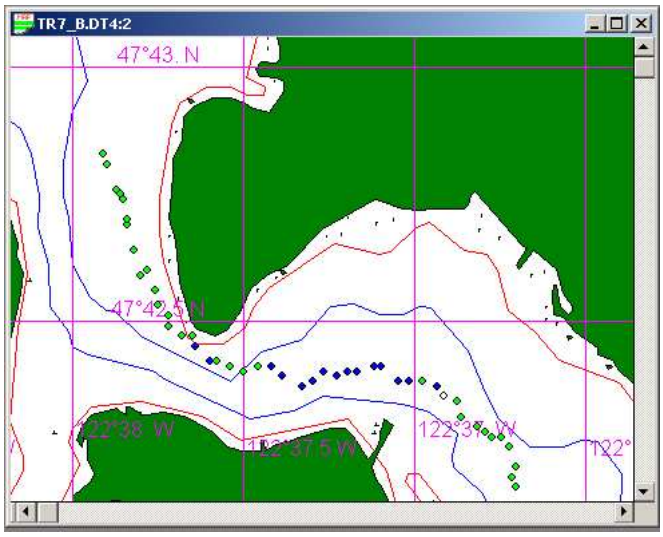
Step 2 Go to `Show Map Window` in the `EDIT MAP` section of the menubar

Step 3 If a map file does not open, go to `Import Map from File` and open C:\BIOSONICS\VBT\MAPS\MAPA.bmp.

Step 4 Go to `Configuration` ▷ `Output Report Filters` and deselect 'Stop analysis after 1 ping'

Step 5 Analyze the data file by pressing

- The algorithm will classify each report of pings according to where the averaged ping falls in feature space (shown in the method window during analysis).
- In the map window, you will see an array of dots. The colors of dots correspond to the colors in the multifile view setting of the method window. In this case, the red dots represent to mud, the green dots represent to sand, the blue dots represent to rock and the white dots represent to unclassified pings. The final output should look as follows:



- In the echogram window, you should see the bottom-type for each ping color-coded along the bottom.

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The methods described in the above tutorial, should be used to establish a ground truth for each of your own data sets. Recall, it is important for unclassified data sets to be collected using the same data acquisition parameters that were used to collect the ground-truth data.

2.2 Preparing Your Data File for Analysis

Once you have generated a ground-truth you are ready to begin classifying your unknown data sets. The first step in classifying your unknown data set is preparing the data file for analysis.

2.2.1 Oscilloscope Window

The bottom tracking algorithm is the first step in the classification process in VBT™ . The bottom tracking algorithm isolates the bottom echo portion of the each ping (See Section 4.1). Before you begin analysis of your data, you need to set up the bottom tracking parameters in the oscilloscope window.

The threshold values and sampling windows may be adjusted either manually or numerically.
The values can be defined numerically by going to `Configuration ▷ Bottom Tracking Parameters` for threshold values and `Configuration ▷ Bottom Sampling Windows` for the sampling windows. Adjusting the values numerically adjusts the visual display in the Oscilloscope window. Similarly, adjusting the values manually updates the values displayed in the CONFIGURATION MENU items.

Tip: Numerical adjustments affect the width of the sampling windows, not their location along the horizontal axis.

Step 1 Adjust the thresholds (horizontal lines).

- Step 1 a The lowest threshold, 'Data Processing Filter Threshold' should be greater than or equal to the 'Data Acquisition Threshold' (found in `Configuration ▷ Data File/ Transducer Properties`).
- Step 1 b The middle threshold, 'Bottom Detection Threshold' can be numerically defined by going to `Configuration ▷ Bottom Tracking Parameters` . The 'Bottom Detection Threshold' should be a few decibels higher than the end of the bottom echo.
- Step 1 c The top threshold, 'Peak Threshold' can be numerically defined by going to `Configuration ▷ Bottom Tracking`

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`Parameters` . The 'Peak Threshold' should be a few decibels below the highest peak in the data file.

In the Oscilloscope window, the sampling windows are represented by vertical, dotted lines. You can manually adjust the width of the sampling windows by dragging right-hand boundary of the window. Dragging the left-hand boundary of the window, allows the user to shift both sides of the window simultaneously, while maintaining the width of the window. Clicking on the left-hand boundary of E1′(the start of the bottom echo) will allow you to shift all windows simultaneously (while maintaining their width and relative positions).

Step 2 Adjust the sampling windows (vertical lines).

The sample windows should be adjusted so that the E1 sampling window (*the second half of the first bottom echo*) has red hatch marks in the oscilloscope window. You can manually adjust the width of the sampling windows by dragging right-hand boundary of the window. Dragging the left-hand boundary of the window, allows the user to shift both sides of the window simultaneously, while maintaining the width of the window. Clicking on the left-hand boundary of E1′(the start of the bottom echo) will allow you to shift all windows simultaneously (while maintaining their width and relative positions). Refer to Section 3.1 for more information on working with the oscilloscope window.

2.2.2 Echogram and Output Report Windows Settings

If you wish to change any of the default settings for the echogram window and output report window (NOT RECOMMENDED), you must make your selections prior to analyzing the data file.

2.2.3 Bottom-Typing Method

Once you have set up the bottom tracking parameters and bottom sampling windows in the oscilloscope windows, you may select the bottom-typing method you wish to use.

Step 3 Select Bottom Typing Method

Bottom-Typing

i Press the corresponding method button in the toolbar

– or –

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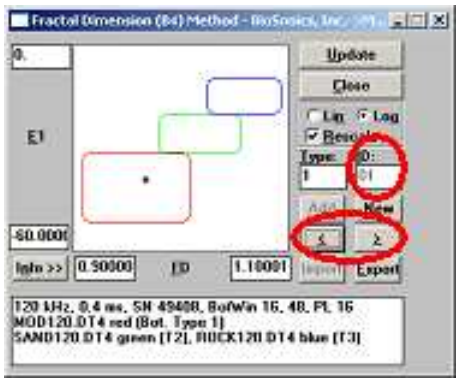
ii Select the the corresponding method from `Select Bottom Typing Method` in the CONFIGURATION MENU

– or –

iii Select the the corresponding method from `Configure Bottom Typing Algorithms` in the CONFIGURATION MENU

Step 4 Select the ground-truth library you wish to use by cycling through the ID buttons.

√ Note: When creating a ground-truth library, record (1) the order in which the feature spaces were created and (2) the data acquisition parameters in the "Info" section for future reference.



Step 5 You are now ready to begin analyzing your data file.

2.3 Analyzing Your Data File

2.3.1 Single Transducer Data Files

Once you have prepared the data file properly (as described in Section 2.2), you may analyze the data file in one of three ways :

Play

- Press the play button located in the toolbar
- Select `Play` from the ANALYZE MENU
- Press 'F5'.

2.3.2 Analyzing Multiplex Data Files

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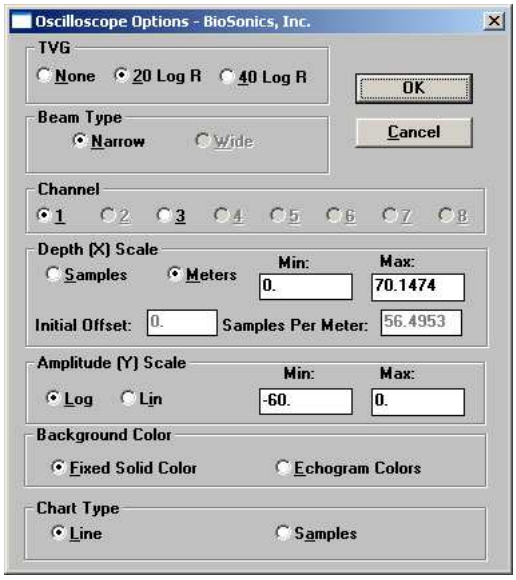

Only one channel can be processed at a time. VBT™ will open the lowest channel number by default. (Channel 1 in this example). You can select the channel you wish to process by going to `Configuration` ▷ `Oscilloscope` and selecting the corresponding channel. If you wish to process another channel, select `go to first ping` in the `VIEW MENU` or toolbar and reanalyze the data. Be sure to review the settings in the oscilloscope window (See Section 2.2.1. New echogram and output report windows will open.

2.4 Interpreting the Analysis Results

2.4.1 Echogram Window

In the echogram window, the bottom-typing results are displayed on the bottom axis. A vertical colored line is present for each bottom-typed ping. The color of the line corresponds to the color of the feature space window for the bottom-type, as defined in the method window. For example, in the tutorial in Sections 2.1.1 & 2.1.2, *mud120.dt4* was the first file opened and therefore has a red feature space box in the method window. In the echogram window, pings that were classified as mud have a red line in the bottom axis. A white line corresponds to an untyped bottom.

2.4.2 Output Report Window

In the output report window, the bottom-typing results are displayed numerically in the 'Type' column, where the number corresponds to the order in which the feature space boxes were created. For example, in the tutorial in Sections 2.1.1 & 2.1.2, *mud120.dt4* was the first file opened and therefore each ping that was classified as mud will have a '1' in the Type Column. A zero is displayed when the bottom was not typed.

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2.4.3 Map Window

If a the map window was open during analysis, the bottom-typing results will be plotted on the map as a color-coded dot at each ping. As in the echogram window, the color-code corresponds to the colors established in the method window. A white dot corresponds to an untyped-bottom.

2.4.4 Improving the Accuracy of the Analysis

Lost Bottom

The first step in the VBT™ bottom-typing algorithm is to isolate the bottom echo portion of each ping (bottom tracking). If the bottom tracking parameters are not properly set, the algorithm may miss may of the bottom echoes. The bottom tracking parameters can be set by going to `Configuration` ▷ `Bottom Tracking Parameters` .

You can determine the number of lost bottoms in your analysis by right-clicking on the echogram window. Each vertical line corresponds to a lost bottom. In order to reduce the number of lost bottoms, we recommend first lowering the 'Alarm Limit' (found in `Configuration` ▷ `Bottom Tracking Parameters`) and re-analyzing the data, by selecting `View` ▷ `go to first ping` and `Analyze` ▷ `Play` .

If the number of lost bottom persists, go to the oscilloscope window and ensure that the bottom sampling windows (defined in `Configuration` ▷ `Bottom Sampling Windows`) are properly positioned. Please refer to Section 4.1 for more information on working with the Bottom Tracking Algorithm.

Untyped Pings

If a large number of the pings in your data file are not assigned a bottom-type during analysis, it is most likely due to small feature space boxes in the method window. When you are creating a "ground-truth" data set, be sure that your feature space boxes fill as much as the feature space as possible. All pings that fall outside of the boxes will be un-typed.

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2.5 Exporting the Analysis Results

Please refer to Section 1.7.4 for information on exporting the results of the analysis.

2.6 Analyzing Batch Files

2.7 GIS Ready Analysis

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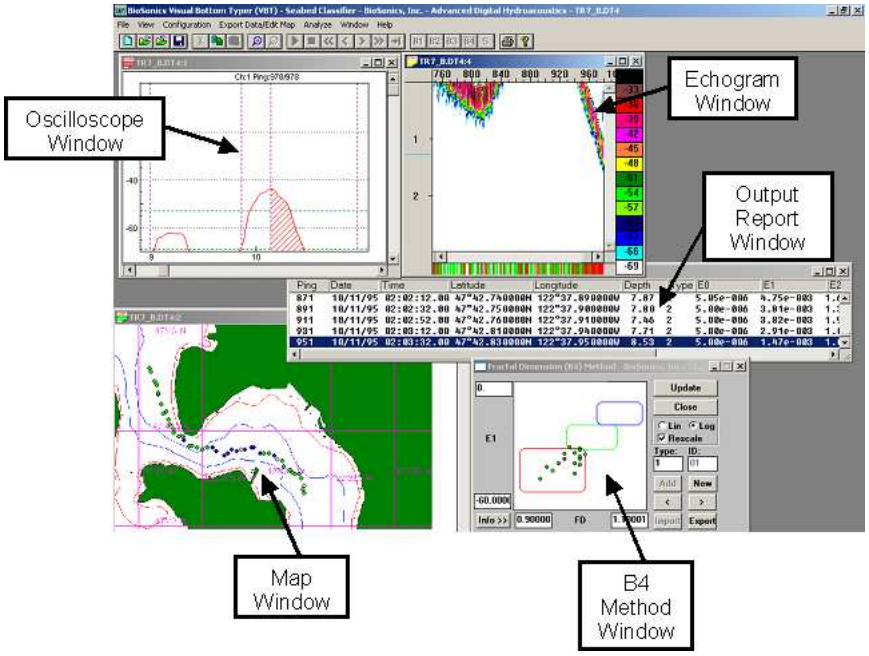
Chapter 3

Manipulating VBT™ Windows

VBT™ includes incorporates user-input in five types of windows (oscilloscope window, echogram window, output report window, map window and bottom-typing method windows) in order to (1) isolate the bottom echo portion of each ping in the data file and (2) use the bottom echo signal to determine the bottom-type.



This chapter provides detailed explanations for working with each of the VBT™ windows.

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3.1 Oscilloscope Window

The Oscilloscope window graphically illustrates a data file by plotting the intensity of each ping along the distance or depth axis. When a data file is opened in VBT™ , the default threshold values and sampling windows are not automatically adjusted to the file, as such the first step after opening a data file is to adjust these values.

The threshold values and sampling windows may be adjusted either manually or numerically. The values can be defined numerically by going to `Configuration ▷ Bottom Tracking Parameters` for threshold values and `Configuration ▷ Bottom Sampling Windows` for the sampling windows.

Tip: Numerical adjustments affect the width of the sampling windows, not their location along the horizontal axis.

Adjusting the values numerically adjusts the visual display in the Oscilloscope window. Similarly, adjusting the values manually updates the values displayed in the CONFIGURATION MENU items.

3.1.1 Analysis Thresholds

As described in Chapter 4.1, the bottom echo of each ping is isolated using two thresholds, the bottom detection threshold and the peak threshold. You can adjust the thresholds manually by clicking and dragging the horizontal dotted lines in the Oscilloscope window (where peak threshold is the top line).

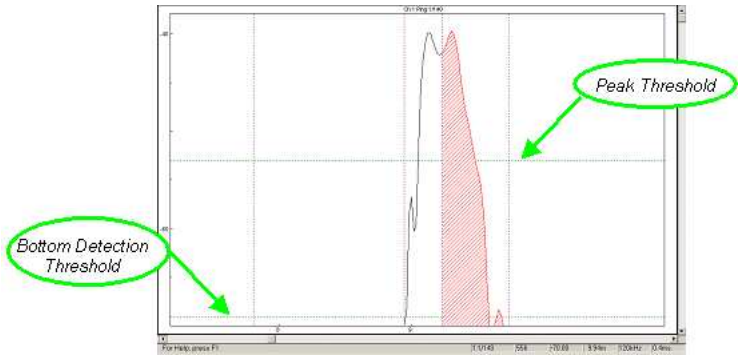

Figure 3.1: Bottom Sampling Thresholds in the Oscilloscope Window

3.1.2 Sampling Windows

There are several sets of sampling windows (represented by vertical lines in the Oscilloscope window). When the sampling windows are defined us-

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ing `Configuration ▷ Bottom Sampling Windows` , the user is defining the width of the sample window (in units of samples), not the placement of the sample window on the horizontal axis.

The following figure illustrates the manner in which sample windows are defined in the Oscilloscope window. Please note the shared boundaries between the S, E1′and E1 windows.

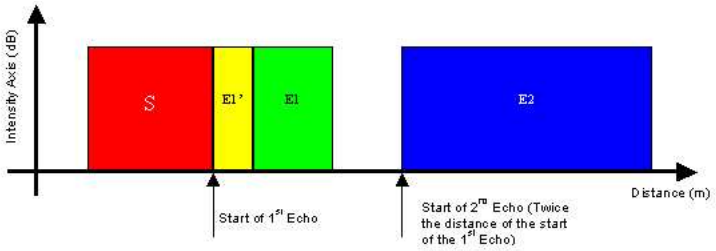

Figure 3.2: An illustration of the arrangement of sampling windows in the Oscilloscope window. Please note the shared boundaries between the S, E1′and E1 windows.

In the Oscilloscope window, the sampling windows are represented by vertical, dotted lines. You can manually adjust the width of the sampling windows by dragging right-hand boundary of the window. Dragging the left-hand boundary of the window, allows the user to shift both sides of the window simultaneously, while maintaining the width of the window. Clicking on the left-hand boundary of E1′(*the start of the bottom echo*) will allow you to shift all windows simultaneously (while maintaining their width and relative positions).

The sampling window boundaries in the Oscilloscope window for S, E1 and E1′are illustrated in the following figure.

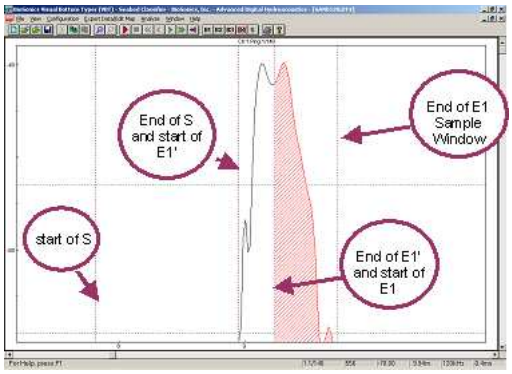

Figure 3.3: An illustration of the sampling window boundaries in the Oscilloscope window for the sediment window and first bottom echo (both parts).

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3.1.3 Zooming

Zoom in & Out

Zoom-in and zoom-out are available in the Toolbar and the VIEW MENU. In addition, you may zoom into the Oscilloscope window drawing a box with the mouse around the area you which to enhance. You may zoom-out by double-clicking in the Oscilloscope window. Several double-clicks will reset the Oscilloscope window to its original size.

3.1.4 Using Color

We recommend customizing the colors in your Oscilloscope window for easier interpretation. The Color options are available in Configuration ▷ Color.

3.2 Method Windows

Although all method windows can be displayed at the same time and running, only one bottom classification method can function at a time in VBT™ . The algorithm performs the classification using the criteria established by the last method window opened. For an in-depth description of working with the method windows, please refer to the tutorials in Chapter 2. Working with Method B1 is not included in this manual.

3.2.1 Components of the Method Window

3.2.2 Methods B2, B3, & B4

The layout is the same for the B2, B3 and B4 method windows. However, The axes and the computational method implemented differ (See Chapter 4.2 for details). Although the methods described in this subsection apply to all three methods, for simplicity, the B4 method window is the only window displayed in the figures.

When working with VBT™ to classify bottom-types, you should use customized parameter sets for each bottom type customized to the region you are studying. The feature space is the white region in the method window and each feature space box represents a different bottom-type.

In VBT™ , you create additional classification sets by clicking on the 'New'

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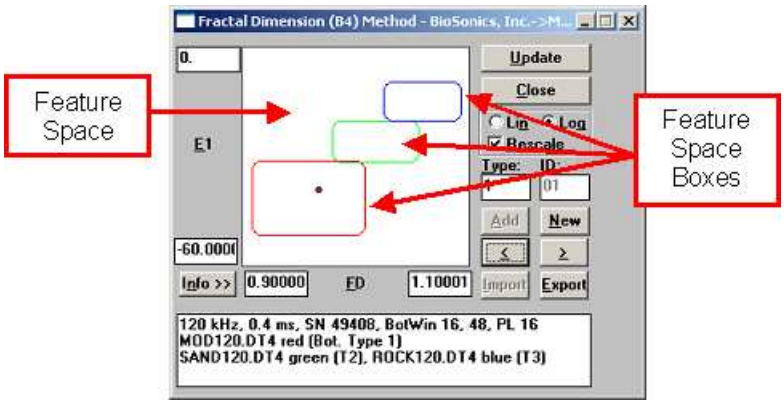
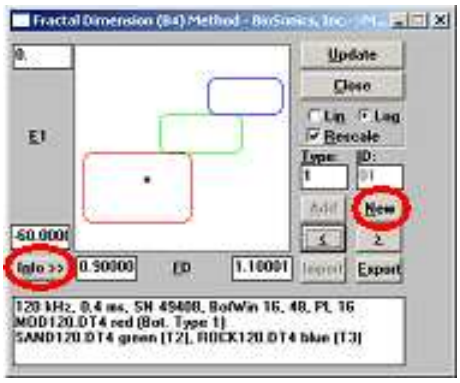
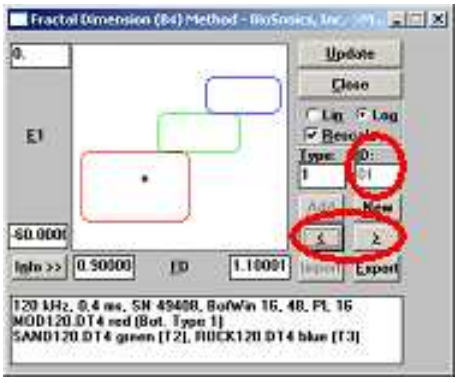


button in the method window you wish to use. You can annotate the classification set by clicking on 'Info' and adding pertinent details, such as location, sampling frequency and pulse duration.



The feature space is numbered in the order in which they were created. The parameter set in use is identified by the ID number, highlighted in the accompanying figure. If you select a parameter set prior to analysis, VBT will classify the bottom using the parameters you selected. Otherwise, VBT™ will classify the bottom using the last parameter set you used. You can move between feature space sets that you created by clicking on the right and left arrows buttons.



You can manipulate the display by manually adjusting the range of the horizontal and vertical axes or select from linear or log for the axes scale. You must select 'Update' to view the changes to axis range. The 'Export' button

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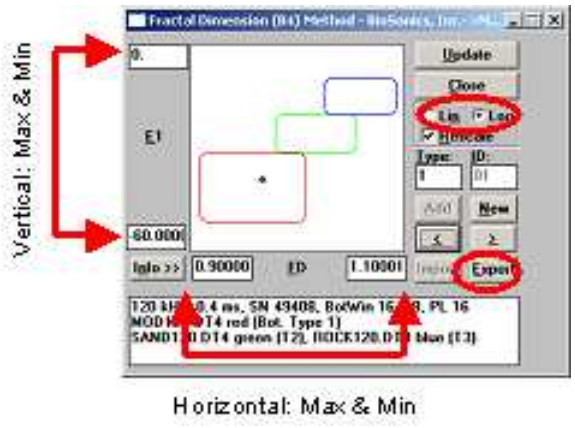
allows you to export the coordinates of each feature space into an ASCII file.



When you right-click on the titlebar or window icon (located in the titlebar) a menu appears.

Move - brings up the double-arrow cursor, which allows you to click and drag the method window. This can also be done by clicking and dragging the window.

Size - allows you to resize the window. This can also be done by moving your cursor to any of the corners of the method window and then clicking and dragging.

Close - closes the method window

Copy - allows you to copy an image of the window to the clipboard, which can then be pasted into another program

Copy to - saves an image of the window to a bitmap file

Report View - allows you to view the averaged ping values for every report from the current data file. The red dots signify average values.

Multifile View - allows you to view the average ping values for every report for all open files. The dots are Color coded in the order the files were opened (red = 1st open, green = 2nd open, blue = 3rd open)

FCM Algorithm - Refer to the following section

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3.2.3 Fuzzy C-Means (FCM) Clustering

The FCM Algorithm allows you to automatically create the feature space boxes contained in the B2, B3 or B4 method windows. The algorithm should be used when generating your ground-truth reference library. (See Section 2.1.1 for a tutorial on working with the FCM algorithm).

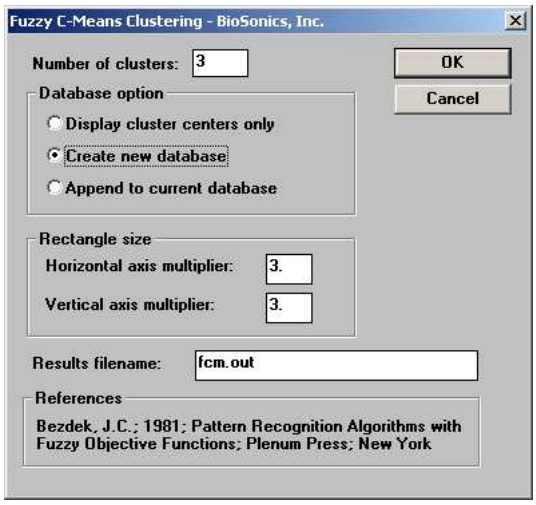

Figure 3.4: FCM Algorithm Options

Number of Clusters - specifies the number of clusters for the algorithm to locate. The number of clusters should always be equal to the number of data files used to generate the ground-truth data.

Display Cluster Centers Only - displays the cluster circles in the all databases and does not display corresponding feature space boxes.

Create New Database - creates clusters and feature space boxes in a new empty database. (The new empty database must first be created by selecting 'New' in the Method window).

Append Current Database - Adds a cluster to the existing database. A cluster will be added for any data file that is open.

Rectangle Size - Allows you to specify the size of the cluster space. A multiplier of one will use dimensions of one cluster variance. A multiplier of three will use dimensions of three times the cluster variance.

Results Filename - datafile where the coordinates of the cluster are stored. Be sure to change the file name, or the default filename will be used and you will lose your previous data.

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3.2.4 Manipulating the feature space boxes

The boxes in the method window can be adjusted using your mouse. The cross-hatch cursor allows you to move the box (while maintaining its shape) and the diagonal cursor allows you to resize the box. You may delete a template, by right clicking on it. Double-clicking on any template will highlight all templates.

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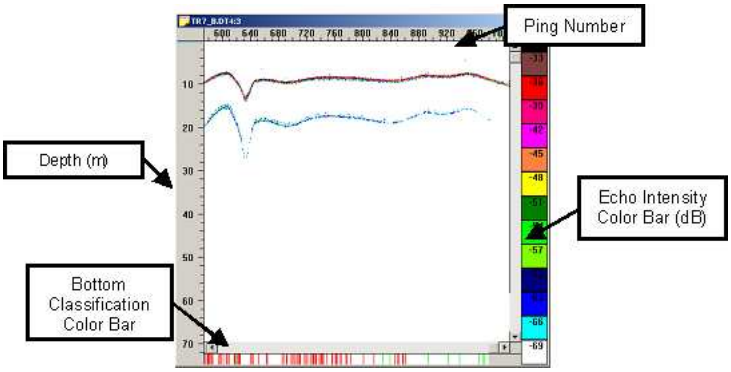
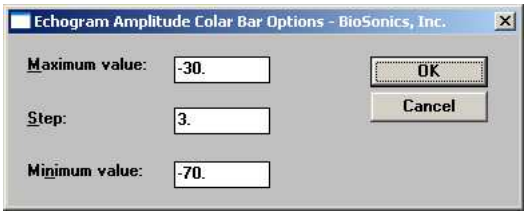
3.3 Echogram Window

The echogram window displays the results of the analysis by graphing the ping number (top horizontal axis) against bottom depth (vertical axis). The depth of each sample in each ping is plotted vertically.



The echo intensity is reflected in the color of each pixel of the Echogram. The echo intensity color bar is displayed on the right hand vertical axis. The color bar can be adjusted by going to `Configuration` ▷ `Echogram Color Bar` and entering the Minimum Intensity (dB), Maximum Intensity (dB) and step between intensities (dB). The order of the colors cannot be manipulated.



The bottom classification of each ping is depicted along the bottom axis. The colors correspond to the colors used in the active Method window. Red corresponds to the first file opened while creating the feature space, green corresponds to the second file and blue corresponds to the third file.

You can zoom into the Echogram window (1) by using the zoom-in and zoom-out buttons in the toolbar , (2) by selecting the options in the `View Menu` or (3) by pressing '=' or '-', respectively. Boxing a portion of the Echogram window will open a new Echogram window using the coordinates of the box.

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3.4 Output Report Window

The output report window is organized by 'ping number' and displays the data numerically for the following fields:

Date - date the data was collected

Time - time the ping was recorded

Latitude - latitude of the ping transmission

Longitude - longitude of the ping transmission

Depth - depth to the bottom

Type - numerical code corresponding to the type of bottom.

- **0** no bottom coded
- **1** corresponds red parameter box (first file opened)
- **2** corresponds to the green parameter box (second file opened)
- **3** corresponds to the blue parameter box (third file opened)

E0 - energy of sediments echo

E1 - energy of second part of 1st bottom echo

E2 - energy 2nd bottom echo

E1′ - energy of first part of 1st bottom echo

Sediment - thickness of the sediment layer

FD - Fractal dimension

In the Configuration menu, 'Output Report Filters' allows you to select: the energy filter and the number of pings per report. Each line in the Output Report Window is one 'report'. The value entered in the energy filter specifies the lowest amount of energy a ping can have to be included in the analysis. The energy filter is in terms of the percent of the maximum energy present in the data file and can be described using the following mathematical approximations.

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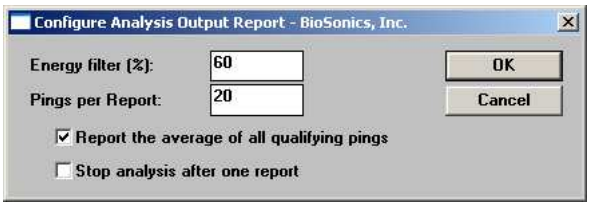
$$EP_i = \int (P_i) dx$$

where EP_i is the energy of the i^{th} ping
and P_i is the ping plotted against depth (x).

EP is calculated for all pings in the data file and the highest value of EP (called EP_{max}) is determined. The energy of each ping is compared to EP_{max} using the ENERGY FILTER:

an output report line is created for all
$EP_i \geq x \cdot EP_{max}$ where x = ENERGY FILTER

For example, the energy filter shown in the figure to the left allows samples with a value of 60% or more EP_{max} to pass and be analyzed by the VBT algorithm.



The 'Pings per Report' option allows you to specify the step size between pings displayed in the output report window, as well any exported report file. When the option 'Report the average of all qualifying pings' is selected, the algorithm returns the average all pings that pass through the filters in a ping step. For example, the output for ping 31 (when pings per report is 20) is the average of all values over 60% for pings 12-31. When the averaging option is not selected, all pings that pass through the filter are displayed.

The option 'Stop analysis after 1 report' stops the analysis after 1 report. If 'report the average of all qualifying pings' is selected, the analysis will stop after 1 ping report and the output report window will show 1 report containing the average of all 'Pings per Report' pings that exceed the energy filter. If the averaging option is not selected, all pings that exceed the Energy filter are reported, for each grouping of 'Pings per Report'. In either scenario, the next report is generated by pressing the play button. This option is extremely useful when customizing feature space using the method windows.

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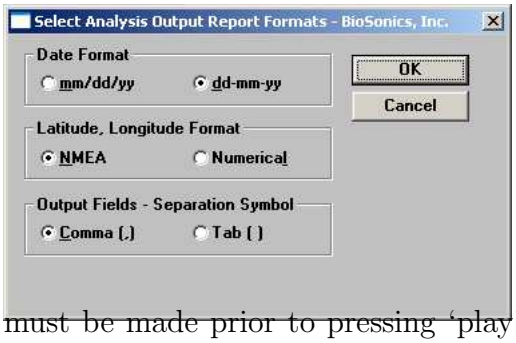
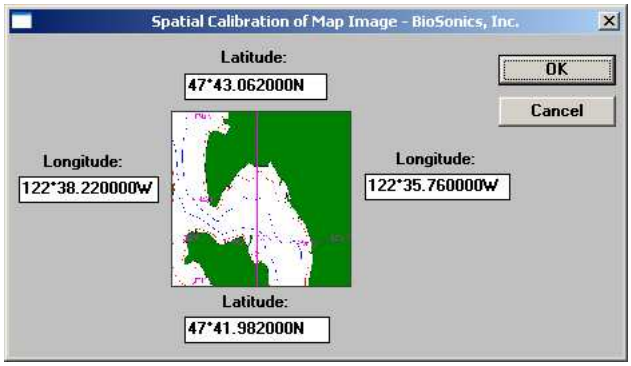


The format for the date, longitude & latitude, and output file are specified in the accompanying window by selecting `Configuration ▷ Output Report Format Options` . Specifications made here will affect both the output report window and any exported report file. Recall, changes must be made prior to pressing 'play'. If the changes are made after 'play' has been used, the effects will take place when the file is reanalyzed. You can specify the data fields to include in the output report window (and any related export files) by going to `Configuration ▷ Output Report Export Fields` .

If you make changes to the output report settings via the CONFIGURATION MENU, while the analysis is in progress, a new output report window will be opened and the remaining data will be displayed in both report windows. If you double-click on a ping in the output report window, it will move to that ping in the oscilloscope window. You can export the output report window by the using `Copy to Clipboard` from the EXPORT DATA MENU or selecting the Copy icon from the toolbar. The information can then be pasted into a spreadsheet.

3.5 Map window

VBT™ allows you to import a map image and label bottom-types directly onto the map. A map image is associated with a file by selecting `Show Map Window` from the EDIT MAP MENU (or CTRL+M). You can select an image to use as a map by going to the EDIT MAP MENU and selecting `Import Image From File` or `Paste Image From Clipboard` . If a map image has already been associated with the file, it will open automatically when you select `Show Map window` .



When you first import a map file, you must define the coordinates of the map. The map coordinates are set by going to `Edit Map ▷ Calibrate Map Spatial Range` and defining the minimum and maximum lat-

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itude and longitude. The highest latitude is defined in the top box. The west-most longitude is defined in the left box. You can also add coordinates by double-clicking on the map window and entering them into the pop-up menu. However, it is recommended that you use the `Calibrate Spatial Range Command` to ensure accuracy. If a map is imported from EchoBase, then the spatial range is entered automatically.

If a map window has been opened prior to analysis, the bottom-types will be labeled (in the appropriate coordinates) directly onto the map file during analysis. The bottom types are defined by the parameter sets defined in the Method window and labeled with colored dots consistent with the color code in the Method window. Unclassified bottom types are identified by white-colored dots. TIP: If the map window is opened after analysis has begun, go to the first ping and reanalyze the data.

VBT™ allows you to use any bitmap or windows metafile file as a map file. It is up to the user to acquire an appropriate image.

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Chapter 4

How VBT™ Works

This chapter provides a brief description of the theory behind the algorithm in VBT™ . The algorithm for VBT™ can be divided into two main parts, (1) the bottom tracking algorithm and (2) the bottom-typing algorithms. In order to perform bottom-typing, VBT™ first identifies the bottom echo portion of the data file using the bottom tracking algorithm described in Section 4.1. Once the bottom echo portion has been isolated VBT™ uses the Bottom-Typing method selected by the user in order to determine the bottom-type. The bottom-typing methods included in VBT™ are described in Section 4.2.

A complete discussion of the algorithms included in VBT™ is beyond the scope of this User's Guide. A sample of the published papers regarding bottom typing algorithms are provided in the appendices for your reference.

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4.1 Bottom Tracking

The purpose of VBT™ is to classify the type of bottom of the seabed by analyzing the signal characteristics of the bottom echo. In order to classify the bottom, the portion of the bottom echo portion of the ping must be isolated. VBT™ uses an algorithm called the 'Bottom Tracking Algorithm' or 'Bottom Tracker' to isolated the bottom echo.

BioSonics, Inc. bottom tracker is an "end-up" algorithm, in that it begins searching for the bottom echo portion of a ping from the last sample toward the first sample. The bottom tracker tracks the bottom echo by isolating the region(s) where the data exceeds a peak threshold for N consecutive samples, then drops below a surface threshold for M samples. Once a bottom echo has been identified , a bottom sampling window is used to find the next echo.

The bottom echo is first isolated by user-defined threshold values that indicate (1) the lowest energy to include in the bottom echo (bottom detection threshold) and (2) the lowest energy to start looking for a bottom peak (peak threshold). The bottom detection threshold allows the user to filter out noise caused by a low data acquisition threshold. The peak threshold prevents the algorithm from identifying the small energy echoes (due to fish, sediment or plant life) as a bottom echo.

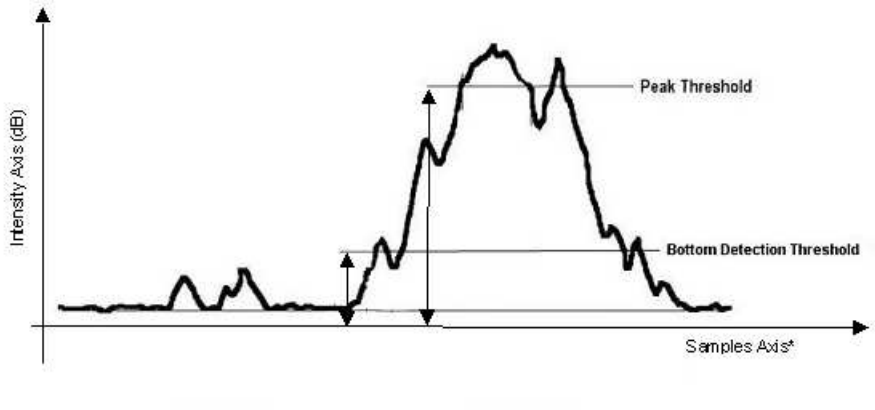

Figure 4.1: Bottom Tracking Thresholds: The Bottom Detection Threshold eliminates noise due to the data acquisition threshold from the bottom echo. The Peak Threshold prevents the algorithm from classifying small echoes (such as fish echoes) as bottom echoes.

To avoid incorrectly identifying small dips or small jumps in the signal as the end of the bottom echo or the peak of the bottom echo, the user can define thresholds windows. The threshold window indicates the smallest number of

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samples in a row that must exceed the threshold in order for the dip or jump to be classified as an end or peak.

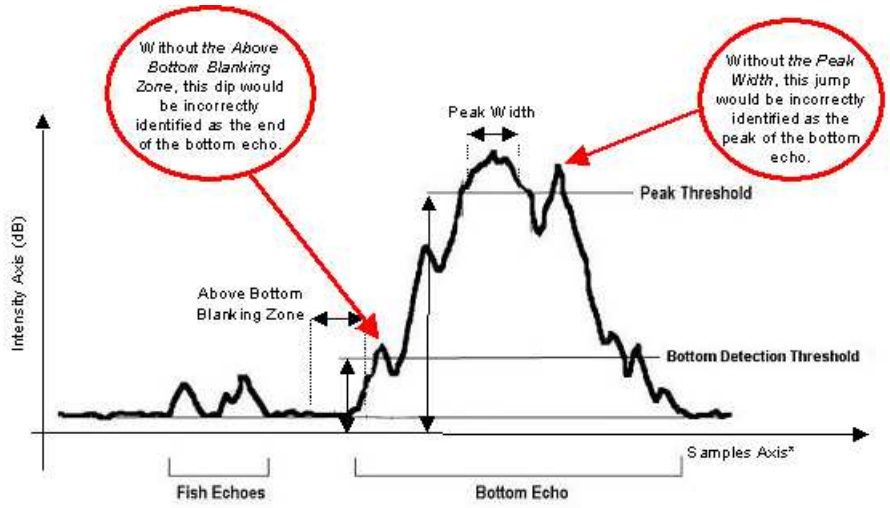
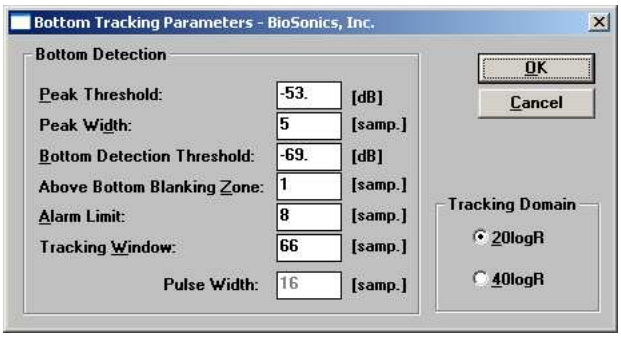

Without the Above Bottom Blanking Zone, this dip would be incorrectly identified as the end of the bottom echo.
Without the Peak Width, this jump would be incorrectly identified as the peak of the bottom echo.
Peak Width
Peak Threshold
Intensity Axis (dB)
Above Bottom Blanking Zone
Bottom Detection Threshold
Samples Axis*
Fish Echoes
Bottom Echo

Figure 4.2: Bottom Tracking Sample Widths: The sample widths prevent the algorithm from incorrectly classifying small jumps and dips as the bottom echo peak or bottom echo endpoint, respectively.

Once a bottom echo has been identified, VBT™ finds the next bottom echo by searching for samples that rise above the peak threshold within a user-defined bottom-tracking window.

If the bottom peak is not found within the window, then the bottom is considered lost. The previously found bottom is assumed to be this ping's bottom. If the number of consecutively lost bottoms exceeds a fixed number (alarm limit), then the bottom tracker is re-initialized and begins searching from the absolute bottom of the ping, rather than the bottom of a window.

The bottom tracking parameters can be defined by the user in `Configuration ▷ Bottom Tracking Parameters` .



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Bottom Tracking Parameters

Peak Threshold The minimum intensity an echo must reach (for PEAK WIDTH number of samples) to be considered a bottom echo

Peak Width The minimum number of consecutive samples an echo must be above the PEAK THRESHOLD to be considered a bottom echo

Bottom Detection Threshold The maximum intensity a portion of the echo must fall below (ABOVE BOTTOM BLANKING ZONE number of samples) to be considered an endpoint of the bottom echo

Above Bottom Blanking Zone The minimum number of consecutive samples an echo must be below the BOTTOM DETECTION THRESHOLD to be considered a bottom echo

Alarm Limit The number of consecutive lost bottoms before the bottom tracking algorithm is reinitialized and the bottom echo is tracked from the bottom of the last ping's bottom echo

Bottom Tracking Window Search window for the bottom-tracking algorithm. The window is centered on the bottom line of the last found bottom and the algorithm searches for the next bottom within the window in both directions.

Lost Bottom When a bottom echo is not found within the 'bottom tracking window' it is referred to as a 'lost bottom'

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Table 4.1: Guidelines for Setting Bottom Tracking Parameters

Parameter	***Typical Range***	***Typical Value***	***Recommendations***
Peak Threshold	-15 dB to -30 dB	-20 dB	Use a high dB for hard bottoms and a low dB for soft.
Peak Width	.06 m to 1.0 m	.09 m	Use a narrow width for hard bottoms and a wide width for soft.
Bottom Detection Threshold	-30 dB to -50 dB	20 dB less than Peak Threshold	Use low dB values for targets far from the bottom.
Above Bottom Blanking Zone	.02 m to .08 m	.02 m	Use wider settings for targets far from the bottom
Alarm Limit	2 to 20	10	Use a high number for inconsistent bottoms
Tracking Window	1 m to 10 m	2 m	Use wide settings for irregular bottoms

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4.2 Bottom Classification Methods

When an underwater acoustic pulse is generated, information about bottom-type (particularly its density and texture), bottom sediments and aquatic plants is embedded in the echo signal. VBT uses signal processing techniques to decode the signal and identify the composition of the seabed bottom. VBT provides four bottom-typing methods for the user, B1[1], B2, B3, and B4.

Each method compares a portion of the bottom echo signal from the unknown data set with the same portion of the bottom echo signal from the ground-truth data set. In Method B1, least-squared-error calculations are used to classify the unknown data set by comparing the energy curve of each ping to energy curves for each bottom type included in the ground-truth data. Methods B2, B3 and B4 use cluster analysis techniques to classify the unknown data set. In these methods, the feature space is divided into regions for each bottom-type (e.g. rock, sand or mud) and the bottom-type for each ping is determined by the feature space it falls into. Table 4.2 provides a summary of the bottom classification methods available in VBT.

The information about hardness and roughness of the bottom is encoded in echo signal envelope. The signal is decoded by taking the time integral of bottom echoes and extraction of hardness and roughness signature. The hardness and roughness signatures can be projected in X/Y coordinates and different types of the bottom can be classified by determining different areas and boundaries of ROUGHNESS/HARDNESS signatures values corresponding to different bottom type (e.g. mud, sand etc.).

√ Note: There are different axes for each of the analysis methods. Method B1 plots the analysis results as energy versus maximum root-mean-square (RMS) error. Methods B2, B3 and B4 plot the analysis results with one axis for each feature used for classification.

[1]Method B1 is generally considered to be obsolete.

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Table 4.2: Summary of Bottom Classification Methods

Method	*Echo Signal Feature Used for Classification*	*Means of Comparison with ground-truth data*
B1	Cumulative Energy Curve of the First Bottom Echo [1, 8]	Least-Squared Error
B2	Energy Ratio(E1/E2) of the Second Part of the First Bottom Echo and the Second Bottom Echo [3, 7]	Cluster Analysis
B3	Energy Ratio(E1′/E1) of the First and Second Parts of the First Bottom Echo [2]	Cluster Analysis
B4	Ratio of the Fractal Dimension of the envelope of the first bottom echo energy (E1/FD) [5, 9, 10]	Fractal Dimension & Cluster Analysis

First Bottom First Part (E1′) The first part of the first bottom echo (from the start to peak). E1′typically corresponds to the hardness of the bottom.

First Bottom Second Part (E1) The second part of the first bottom echo (from the peak to the end). E1 typically corresponds to the roughness of the bottom.

Second Bottom (E2) The second echo from the bottom (resulting from the same ping as the first echo from the bottom)

4.2.1 Method B1 - First Echo Normalization

The First Echo Normalization (B1) method developed by Pouliquen and Lurton (3) is generally considered to be obsolete. An explanation of the method is provided for historical purposes.

The First Echo Normalization method was developed by Pouliquen and Lourton (1). This method is quickly becoming obsolete and is included in the manual for historical purposes. This signal processing technique characterizes the signal by sampling the 1st echo signal from the bottom with a wide window (several pulse lengths) and calculating the cumulative energy curve of the echo. The cumulative energy curve is built for each echo signal (cumulative time integral of squared echo envelope) and averaged over a user-specified number of pings. Different types of the bottom (e.g. mud, sand, rock) will produce curves of different shapes. A hard bottom will produce a sharp bot-

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tom echo with high amplitude while a soft bottom will produce an elongated echo with lower amplitude.

The cumulative curve of an echo signal acquired during survey is then compared with verified standard curves. The bottom-type of an unknown signal is determined by taking the least squared error between the unknown curve and previously classified curves. Figure 1a displays examples of echoes from hard and soft bottom. Figure 1b displays the integral of the squared echo.

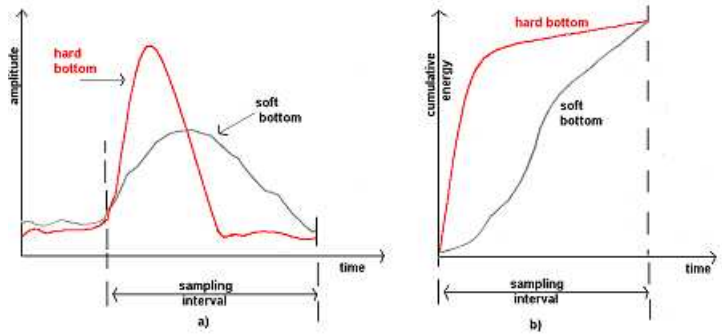

Figure 4.3: Different shapes for hard and soft bottom. a) Echo Signal Amplitude, b) Cumulative Energy Curve.

4.2.2 Method B2 - First/Second Bottom Ratio

The First/Second Bottom Ratio Method (B2) used in VBT™ is based on a bottom-typing method developed by Orlowski (2) and further researched by Chivers *et al*(1). The method was first commercialized by SonaVision, Ltd with their Rox-Ann product line.

Following Chivers *et al*(1), VBT™ Method B2 uses the "hardness" and "roughness" signatures of the bottom echo to identify the bottom-type. E1′(*first part of the first bottom echo*) contains the hardness signature of the bottom, E1 (*second part of the first bottom echo*) contains the roughness signature of the bottom. E2 (*the second bottom echo signal*) also contains the bottom hardness signature.

Figure 4.2.2 illustrates the formation of the first bottom echo (E1′and E1). The initial part of the first bottom echo (E1′) is caused by the first reflection from the surface perpendicular to the transducer axis. This part of an echo (specular and coherent) is very sensitive to pitch and roll of the vessel and the transducer. The remainder of the first bottom echo (E1) is caused by oblique back reflection (non-coherent) and is less sensitive to pitch and roll.

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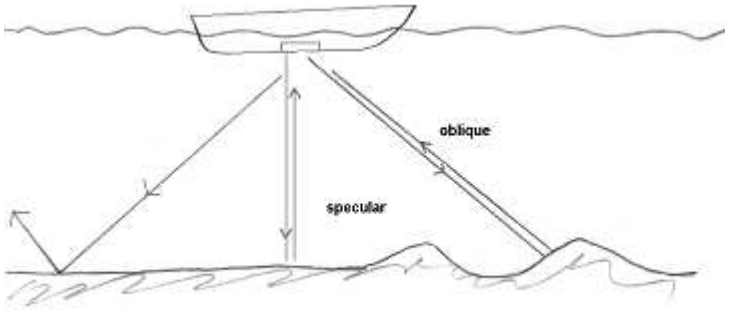

Figure 4.4: Formation of the first bottom echo (E1′and E1).

Figure 4.2.2 illustrates the formation of the second bottom echo. The second bottom echo is produced by a double specular reflection from a seabed and single reflection from the surface of the water. For a flat bottom the specular reflection is directly related to the hardness of the bottom. If the bottom is rough, the second bottom echo will be weak.

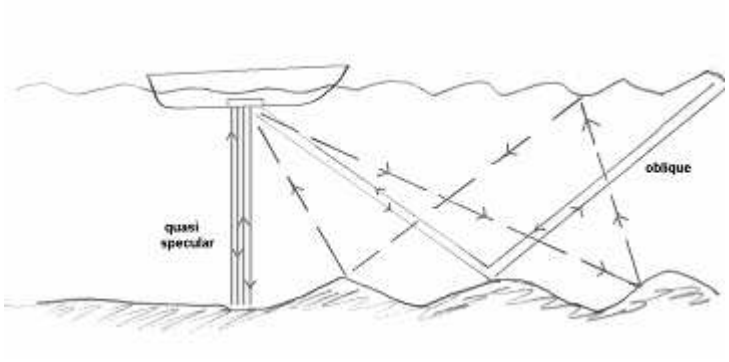

Figure 4.5: Formation of the second bottom echo (E2).

Method B2 calculates the energy of E1 and E2 for each ping in the unclassified data set and plots the pings accordingly, where E2 is the vertical axis and E1 is the horizontal axis. The bottom-type of each ping is determined by the placement of the feature space boxes, previously generated from the ground-truth library.

4.2.3 Method B3 - First Echo Division

Method B3 classifies the bottom-type based on the ratio of the first and second parts of the first bottom echo (E1′/E1). The first part of the 1st bottom echo (building up from beginning of a bottom echo to maximum) contains the bottom hardness signature. The second part of the 1st bottom

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echo decaying part of the pulse after signal maximum contains the bottom roughness signature. The bottom echo is formed in three distinct phases (Figure 4.2.3):

Phase 1 - attack - from the moment the pulse reaches the bottom until the time when the bottom is reached by the back slope of the pulse.

Phase 2 - decay - beginning at the end of attack phase and lasting until the time when the front of the pulse reaches the boundary of the ideal beam pattern.

Phase 3 - release - lasting until the time when the pulse completely enters the bottom.

During Phase 1, the echo is due to a surface reverberation; the reverberation area is circular with diameter increasing with time (time equal approximately to pulse duration). Phase 2 is combination of surface and volume reverberation. During Phase 3 the volume reverberation determines the bottom echo and the reverberation area has a shape of doughnut.

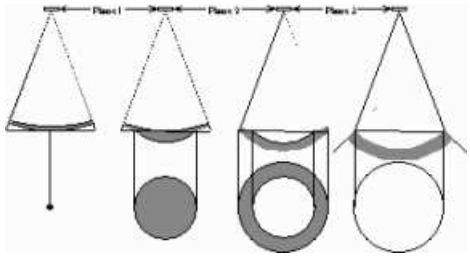

Figure 4.6: Succeeding phases of the sounding pulse propagation for an ideal beam pattern.

After the release phase is complete, in the case of an ideal beam pattern, the only source of the echo can be the reverberation due to bottom volume inhomogeneity. This can be observed especially in the case of soft bottom-types, for which the main part of the echo energy penetrates the bottom. The example in Figure 4.2.3 shows the model echo envelope generated by a soft bottom and Figure 4.2.3 shows the model echo envelope generated by different types of the bottom (fine sand, sand, gravel and rock).

Method B3 calculates the energy of E1′and E1 for each ping in the unclassified data set and plots the pings accordingly, where E1′is the vertical axis and E1 is the horizontal axis. The bottom-type of each ping is determined by the placement of the feature space boxes, previously generated from the ground-truth library.

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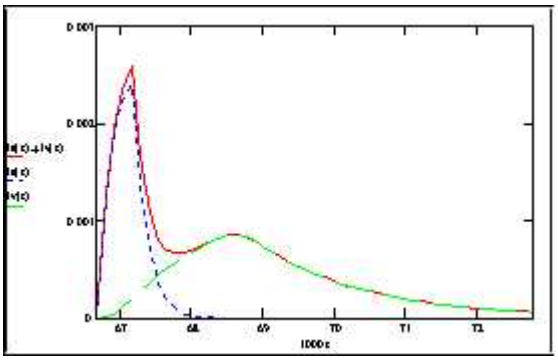

Figure 4.7: Results of echo envelope simulation for soft mud using an ideal (cone) beam pattern of 26^o width. (bottom surface reverberation (blue), bottom volume reverberation (green), - sum (red).

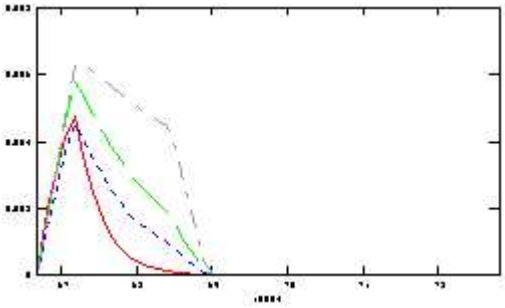

Figure 4.8: Results of echo envelope simulation for different types of the bottom: fine sand (red), sand (blue), gravel (green) and rock (grey) taken using a 26^o transducer.

4.2.4 Method B4 - Fractal Dimension

Method B4 classifies the bottom-type by characterizing the shape of the bottom echo. It is known that the shape and structure of a bottom echo curve is unique to the bottom-type. However, the curve is a complex structure that cannot be simply defined in Euclidean geometry . Fractal dimensions can be used to describe complex shapes (such as an energy curve) by treating the complex shape as a collection of simple geometric shapes. The fractal dimension (FD) of a geometric shape is equal to:

$$FD = \frac{\log N}{\log S} \tag{4.1}$$

where N is the number of self-similar parts contained within the shape and S is magnification factor required to make one self-similar part the size of the original shape.

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For example, an equilateral triangle can be divided into four equally sized triangles (N is four).

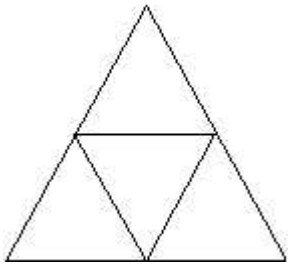

Figure 4.9: Equilateral triangle containing four self-similar equilateral triangles

A self-similar part needs to be magnified by two to equal the size of the original shape (S is two).

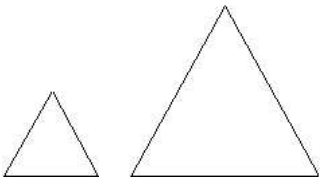

Figure 4.10: A) self-similar triangle from Figure 4.2.4 B)Original triangle in Figure 4.2.4. Magnifying the self-similar triangle by two, results in the original triangle.

Since, the value of $\frac{\log(4)}{\log(2)}$ is equal to two, the fractal dimension of the triangle is two (which is also equal to its Euclidean dimension). Method B4 in VBT™ performs a similar calculation on the energy curve of E2 (*the second part of the first bottom echo*).

4.2.5 Method S - Sediment Layer

The time integral of echo signal envelope is calculated for this depth layer. The user can apply the echo integration model without attenuation or with attenuation. For the signal with attenuation the user should find extinction and attenuation parameters by experiments (most likely sigma back-scattering per kg and sigma extinction per kg). Back-scattering and extinction parameters can be entered by a user into "Parameters" dialog box using menu command Options Transducer. We expect that this layer can be used for quantitative estimate of aquatic plants, from bottom fish and also from sediments. A backtracking bottom tracking method is used in the VBT™ software. This means that the software begins to track the bottom from the far end of the received echo and moves toward a shorter range. Then, the

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bottom tracker locks to the rising edge of the first bottom echo. The sediment layer is at the range before the bottom echo (i.e. it is the layer above the bottom). The sampling gate called in VBT "sediment layer" is open for sampling either sediment or bottom plant echoes. The VBT software is estimating the thickness of this layer and also the integral of the echo.

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Fuzzy C-Means (FCM) Clustering The VBT software version 1.5 includes the FCM (Fuzzy C-Mean Clustering) algorithm for automatic classification of fields for different bottom categories in x/y coordinates for methods B2, B3, B4.

Fuzzy C-Means (FCM) is a data clustering technique wherein each data point belongs to a cluster to some degree that is specified by a membership grade. This technique was originally introduced by Jim Bezdek, (1981) as an improvement on earlier clustering methods. It provides a method to group data points that populate some multidimensional space into a specific number of different clusters. FCM algorithm starts with an initial guess for the cluster centers, which are intended to mark the mean location of each cluster. The initial guess for these cluster centers is most likely incorrect. Additionally, FCM assigns every data point a membership grade for each cluster. By iteratively updating the cluster centers and the membership grades for each data point, FCM iteratively moves the cluster centers to the "right" location within a data set. This iteration is based on minimizing an objective function that represents the distance from any given data point to a cluster center weighted by that data point's membership grade. Figure 4.2.5 shows clustering of Fractal Dimension data.

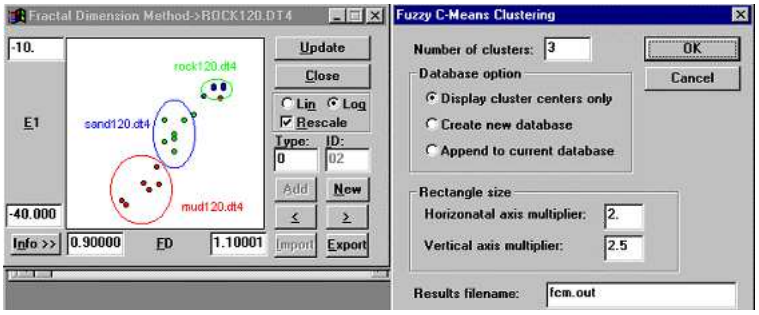

Figure 4.11: Fuzzy C-Means Clustering technique for different bottom categories. Fractal Dimensions method B4 for data files from VBT Catalogue: *mud120.dt4*, *sand120.dt4* and *rock 120.dt4*.

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Appendices

Editor's Note: The scientific papers included in Appendices A, B,& C are translated from Polish into English are were only edited for spelling and basic grammar. The original integrity and writing style were maintained.(CJC)

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Appendix A

Method B1 - Publication

Method Of The Sea Bottom Classification Using Bottom Echo Cumulative Energy Curves
vspace.1in Dariusz Bakiera
Technical University of Gdansk

A.1 Introduction

Pouliquen and Lourton proposed a method of sea bed classification using cumulative curve of echo-signal envelope. They assume the shape of the cumulative energy curve should have a distinct shape and it should be different for different bottom classes. The parameter used to describe the shape of the echo envelope is a cumulative sum of energy of an echo signal normalized to the total energy according to the following formula:

$$E'(t) = \frac{\int_0^t s(\tau)\, d\tau}{\int_0^{T_{max}} s(\tau)\, d\tau} \qquad t \in [0, T_{max}]$$

where: s(τ) is the amplitude of echo envelope signal.

The echo signal envelope is digitized and than processed. In order to minimize the fluctuation of the echo envelope, the normalized sum is calculated (as a signal integral in a discrete time). As a next step of processing, the obtained result is averaged over a number of pulses (e.g. 5 to 10). Averaged cumulative echo curves are compared with theoretically obtained model curves (corresponding to different bottom types). The curve most similar to the received echo (determined using minimum mean square error algorithm) is treated as the corresponding bottom type. The schematic diagram of the processing algorithm is shown on Fig. 1.

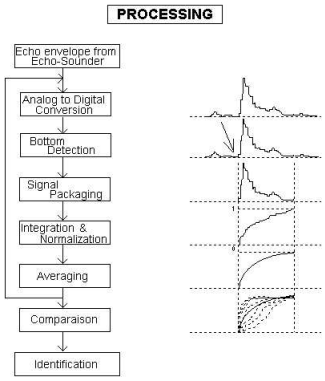

Figure A.1: Algorithm of bottom classification with cumulative curves method.

Pouliquen and Lourton used seven standard curves for bottom type identification, which were obtained using model of bottom reverberation for rock, gravel, sand, very fine sand, muddy sand, mud and soft mud. Reverberation model is based on Kirchoff method (tangential plane area for the surface reverberation and disturbance for volume reverberation). Examples of model standard curves obtained by Pouliquen and Lourton are presented on the Fig. 2.

The purpose of this report is to describe an attempt to create standards which may be used in bottom classification from known experimental data (e.g. recorded bottom echoes for verified bottom samples).

A.2 Results

Echo signals were acquired with following frequencies: 38 kHz, 120 kHz and

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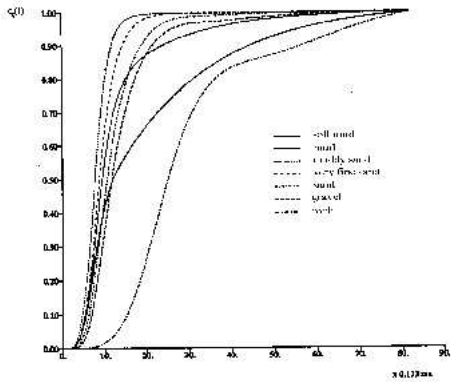

Figure A.2: Set of normalized and integrated theoretical amplitude envelopes E'(t), H = 50 m, directivity of the transducer 16^o, frequency 38 kHz, by Pouliquen and Lourton.

420 kHz. For the 38 kHz and 120 kHz frequencies, the bottom echo signals were recorded for the following bottom types: rock, sand, soft sand and soft mud. For 420 kHz frequency, the bottom echo signals were acquired for rock, sand, mud and mud with gravel.

In order to assess the influence of oblique reflection from the bottom, each series of data was analyzed in two ways. First, by taking into account only perpendicular echoes and and second, averaging all echo signals for a given class of the bottom. Echoes were filtered by selecting local maxim of amplitude. Those echoes containing local maxima were assumed to be formed by a perpendicular reflection from the bottom. For 420 kHz data, two data sets were available, one with a pulse duration of $\tau = 0.4$ ms and the other with a pulse duration of $\tau = 0.4$ ms. Standard curves for the different pulse durations are displayed in the following figures.

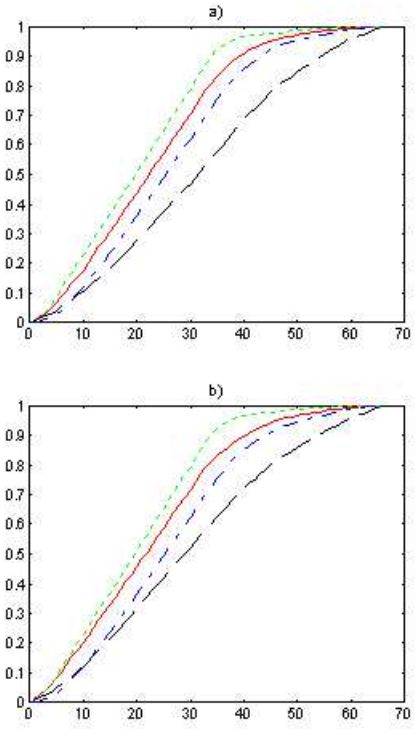

Figure A.3: Standard curves acquired for 38 kHz: a) echoes with maximum amplitude, b) averaged for all echoes,(- rock, .. sand, – soft mud -. mud & sand).

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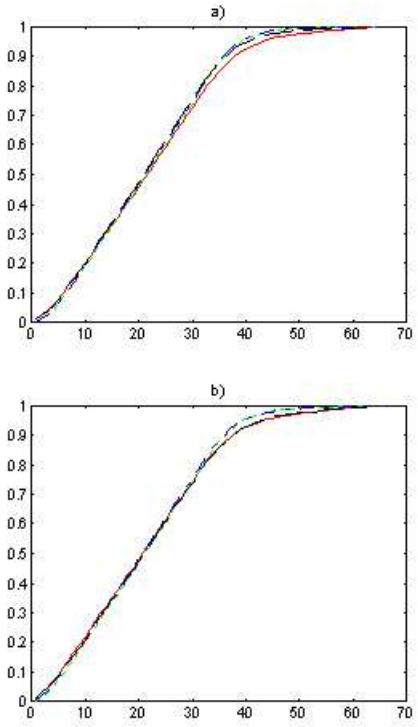

Figure A.4: Standard curves acquired for 120 kHz:a) for echoes with maximum amplitude,b) averaged for all echoes,(- rock, .. sand, – soft mud -. mud & sand).

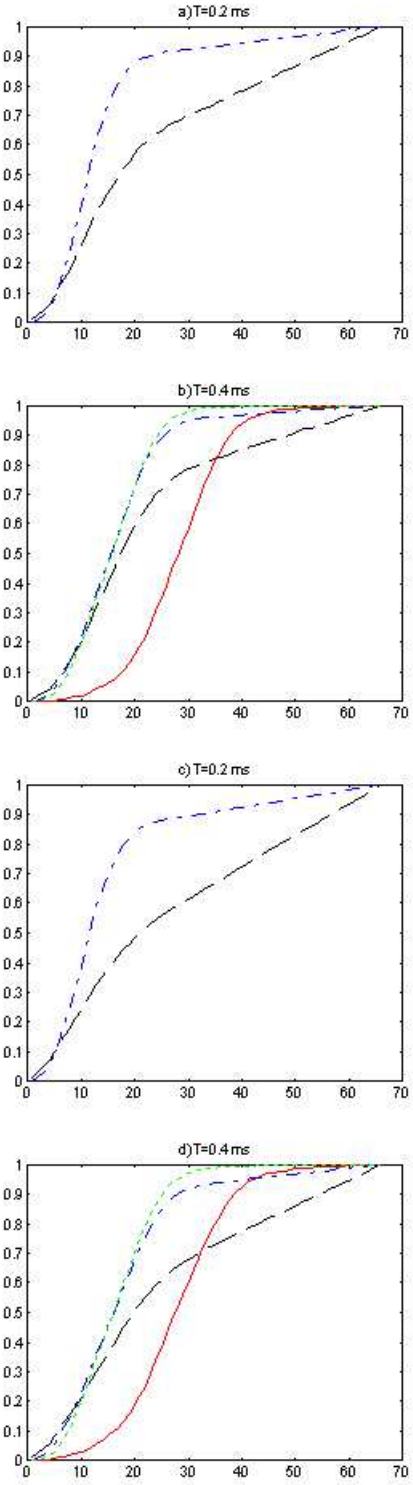

Figure A.5: Standard curves acquired for 420 kHz: a),b) echoes with maximum amplitude, c),d) averaged for all echoes,(- rock, .. sand, – soft mud -. mud & sand).

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A.3 Discussion

For all processed data the standard curves obtained for maximum amplitudes echo are less distinguishable from each other than in the case of all echoes averaged. This indicates that echoes obliquely reflected from the bottom preserves the same or similar shape as echoes reflected perpendicularly.

Useful results for bottom classification do not have clear dependence from signal frequency. Standard cumulative energy curves obtained for 120 kHz are less distinguishable from each other for different bottom type than curves obtained in each set of bottom class. In this case bottom classification would be not possible with this method. Better results were obtained for 38 kHz. However, for 420 kHz the standard curves have distinct different shape for different bottom classes. For 420 kHz, curves for sand and sand with mud have a similar shape, while remaining tow classes of the bottom i.e. rock and mud produce curves of distinct different shape.

A.4 Reference

E. Pouliquen and X. Lourton. "Sea bed classification using echo sounder signals." *Proceedings of European Conference on Underwater Acoustics*. Luxembourg, Sept. 1992. 535-538.

```
LIST OF FILES:
a)38 kHz:
rock38w1.dt4
sand38w1.dt4
ssan38w1.dt4
smud38w1.dt4
b)120 kHz:
hardsand.dt4
rock.dt4
softmud.dt4 (+)
softsand.dt4
c) 420 kHz:
mud420a.dt4 (+)
mud420b.dt4 (+)
rock420a.dy4 (+)
samd420a.dt4 (+)
samd420b.dt4 (+)
sand420a.dt4
d) 420 kHz - "PEPIN" files from Bruce Sabol:
11 files:  pepin_1.dt4 do pepin_11.dt4
(+)
```

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Appendix B

Methods B2 & B3 - Publication

Method Of The Sea Bottom Classification
With A Division Of The First Echo Signal
And
Using First/Second Bottom Signal Ratio[1]

Dariusz Bakiera, Andrzej Stepnowski
Technical University of Gdansk

B.1 Introduction

Information retrieved from sea-bottom echo can be applied in fisheries, hydrography, marine engineering, environmental sciences and other fields. Acoustic methods used to identify the bottom and bottom sediments are the subject of extensive research. Attempts to create uniform classification systems for various shelf seas and ocean areas do not yield the expected results. The vast variety of types of sediments, as well as various geomorphologic forms and the layer structure, make it difficult to determine the types of sediments with acoustic methods. The correlation between physical and statistical parameters of the bottom echo and the types of sediments, are neither unique nor explicit in terms of the majority of the various areas of the World Ocean. The acoustic methods of sea bottom classification encompass following approaches:

- measurement of energy ratio in the first and second echo reflected from the bottom [2,3].
- comparison of the shape of cumulative averaged envelope of a bottom echo with patterns obtained from theoretical models of bottom reverberations [5].
- comparison of measured parameters of the echo envelope to parameters calculated from the theoretical models of reflection from lossy bottom [1,6].
- analysis of a set of values of acoustic and statistical parameters of the echo envelope of reverberation signals using algorithms of neural networks or cluster analysis [4].

This paper describes rather simple method of sea bed classification, which can be implemented using single beam echosounder and a personal computer.

B.2 Method of sea bottom classification with the first echo division

Classification of sea-bottom can be done by estimating two parameters encoded in the echo signal envelope: hardness and roughness. The parameters can be extracted by taking of the integral of sea bed echo envelope in respective time intervals. Information on hardness and roughness of the bottom is embedded in the part of echo signal related to backscattering on the boundary water/bottom. In order to perform bottom classification, it is necessary to split the two components of an echo signal i.e. one caused

[1] EDITOR'S NOTE: The editor (CJC) acknowledges and regrets that an explicit explanation of Method B2 is not included within this text

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by a surface reverberation (hardness signature) and the other caused by a volume reverberation (roughness signature). The volume reverberation can be treated as a disturbance which should be minimized. The attempt to split two signal components from the first bottom echo signal were done based on numerical simulation results of echo signal envelope back-scattered from the bottom [1].

Models of sea bottom echo envelopes, computed for the ideal beam pattern and a plain, homogeneous bottom showed that the certain phases of signal can be distinguished in the bottom echo envelope. Examples are presented on the Fig. 1, showing that distinct phases of an echo signal are independent of the class of the bottom and dependent upon the geometrical configuration of the model.

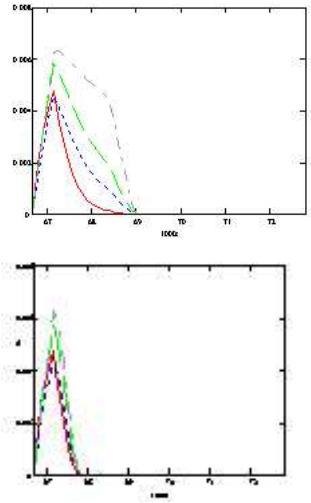

Figure B.1: The results of echo envelope simulations for bottom types: fine sand, sand, gravel and rock for ideal (cone) beam pattern of a) 26^o and b) 13^o width.

Distinct phases of the echo signal can be observed more clearly for hard bottom types. The phases of the echo signal related to acoustic pulse propagation are projected on the Fig. 2. According to Fig. 2, the phases of bottom echo formation can be described as follows:

- phase I (FAZA I) - attack - from the moment the pulse reaches the bottom until the time when the bottom is reached by the back slope of the pulse
- phase II (FAZA II) - decay - beginning at the end of attack phase and lasting until the time when the front of the pulse reaches the boundary of the ideal beam pattern
- phase III (FAZA III) - release - lasting until the time when the pulse completely enters the bottom.

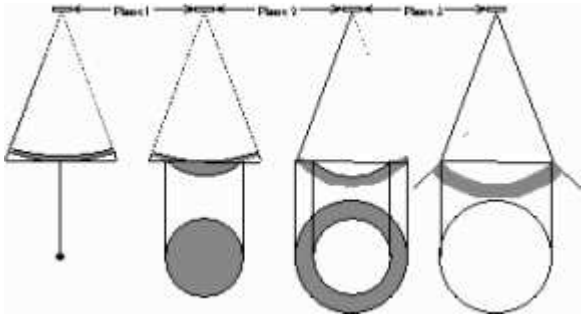

Figure B.2: Succeeding phases of the sounding pulse propagation for an ideal beam pattern.

For long pulses and for narrow beam transducers, Phase II will be shorter until it disappears completely (see Fig. 1.b).

In the case of an ideal beam pattern, after the end of the release phase, reverberations due to bottom volume inhomogeneities are the only source of the echo. This phenomena is prevalent in

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the case of soft types of the bottom, for which the main part of the echo energy penetrates the bottom. Fig. 3 illustrates the model echo envelope generated by a soft bottom.

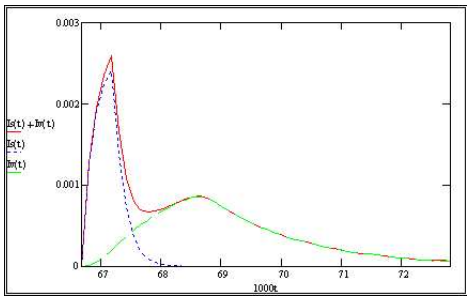

Figure B.3: The results of echo envelope simulation for soft mud in case of an ideal (cone) beam pattern of 26^o width. (.. bottom surface reverberation, – bottom volume reverberation, - sum)

In the case of a real beam pattern (with a side lobes) the part of the signal that reaches the transducer after the ending of the release phase is due to bottom surface scattering. It is however received mainly by the side lobes of the beam pattern and the reception is done at a wide angle, so its level is negligible (according to Lamberst's law). The real beam pattern influence appears also in spreading of decay and release phases limits (see Fig. 4).

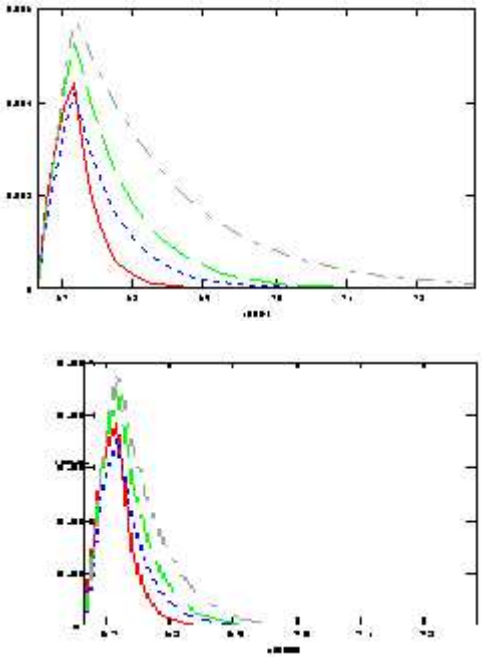

Figure B.4: The results of echo envelope simulations for bottom types: fine sand, sand, gravel and rock for ideal (cone) beam pattern of a) 26^o and b) 13^o width.

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For a real beam pattern with an obliquely reflected pulse with side lobes, this part of echo arrives when the reverberation surface no longer circular but donut-shaped and lasts until the whole pulse penetrates the bottom.

The limits of appropriate phases can be calculated using some geometric and pulse parameters (beam pattern width, water depth, pulse length, etc.):

$$t_0 = \frac{2H}{c_0}$$

$$t_1 = \frac{2H}{c_0} + \tau$$

$$t_2 = \frac{2H}{c_0 \cos\theta}$$

$$t_3 = \frac{2H}{c_0 \cos\theta} + \tau$$

where:

H	=	water depth
c_0	=	sound propagation velocity in water
τ	=	sounding pulse length
t_0	=	start of the echo
t_1	=	start of the decay phase
t_2	=	start of the release phase
t_3	=	end of the release phase
θ	=	half beam width of the transducer

Alternatively, the phases limits can be found using envelope maximum localization. The beginning of decay phase is localized at the maximum of an envelope, while the end of this phase corresponds to the point where the extension of echo envelope crosses the time coordinate.

The signal received during the attack phase is primarily due to specular reflection from the bottom surface. Its amplitude is determined by the ratio of acoustic impedance of the sea water and the bottom material. As a result, it was assumed the energy of the echo within the attack phase boundaries can express the bottom hardness signature:

$$E1' = \int_0^{\tau} V_1^2(t)dt$$

The attack phase starts at the start of the echo signal and its duration equals the sounding pulse length.

During the decay and release phases, the echosounder transducer receives signals scattered at oblique incidence on the bottom surface. The higher the bottom roughness the higher the amplitude of this component [2]. Therefore the integral of the echo envelope in the range of the decay and release phases is treated as a measure of bottom roughness:

$$E1 = \int_{\tau}^{t(V_{max}-60dB)} V_1^2(t)dt$$

The threshold 60 dB in the above formula is an arbitrary threshold that sufficiently minimizes the disturbance level for estimated parameter. During these two phases an increasingly stronger echo signal (originating from volume reverberations in the bottom) interferes with the bottom-typing process. As such, the integration interval should be selected in a way that will minimize these effects. In order to do this, the start of the decay phase should be located in the envelope maximum and its end at the point when the decaying slope of the echo decreases to -60 dB level (corresponding to the moment the pulse completely penetrates the bottom) [1]. The value of the threshold is the result of

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the analysis of the experimental data. Such a selection of integration boundaries will assure elimination of influence of volume reverberation component for its roughness when this level is low (Fig. 3.). In order to eliminate the influence of the pulses scattered at oblique incidence, the echoes reflected at normal incidence should be extracted from the series of data. A simple method of classification was used, based on extracting pulses that were presented as local maximums in the series of pulses.

To show the effect of obliquely scattered pulses, the results of the analysis of the whole amount of data are presented. To retain the readability of the diagrams, the results of the total series analysis were averaged in the groups of equal size. The averaged results are presented in the figures.

B.3 Results

Analysis was performed for hydroacoustic signals from four types of the bottom: rock, sand, soft sand and soft mud. The frequency of the echosounder was 38 kHz and 120 kHz. Two series of data were analyzed for every class of the bottom, one for each frequency (Fig. 5). For comparison, classification with another method was also performed. The other method classifies the signal using an integral of the second echo envelope as a measure of bottom hardness (Fig. 6):

$$E2 = \int_0^\tau V_2^2(t)dt$$

For the 420 kHz data, bottom signals were from four types of the bottom: rock, sand, mud and mud with sand. Since most of the data for 420 kHz did not contain second bottom echo, it was not possible to compare the first bottom method and the first/second bottom method. For this data set, the figures illustrate the results for two pulse lengths: $\tau = 0.2$ ms and $\tau = 0.4$ ms (Fig. 7).

In order to visualize the influence of pulses reflected obliquely from the bottom, for each series of measured data, the results were processed for all pulses. For clear visualization of processed data, the pulses were averaged over a specific number of consecutive pulses (e.g. 20 pulses). The averaged data is presented in the figures.

The results of the classification are presented as points on scattering diagrams (Figs. 5, 6 and 7):

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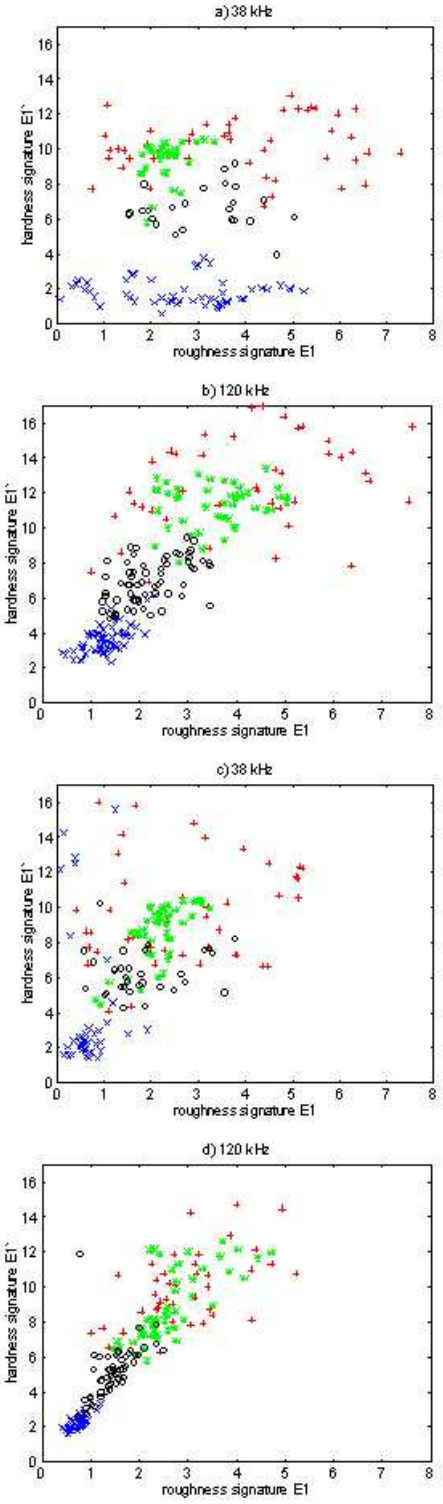

Figure B.5: Classification results for first echo division method:a), b)pulses with maximum amplitude, c), d) averaged for all pulses (+ rock,* sand, o soft sand, x soft mud

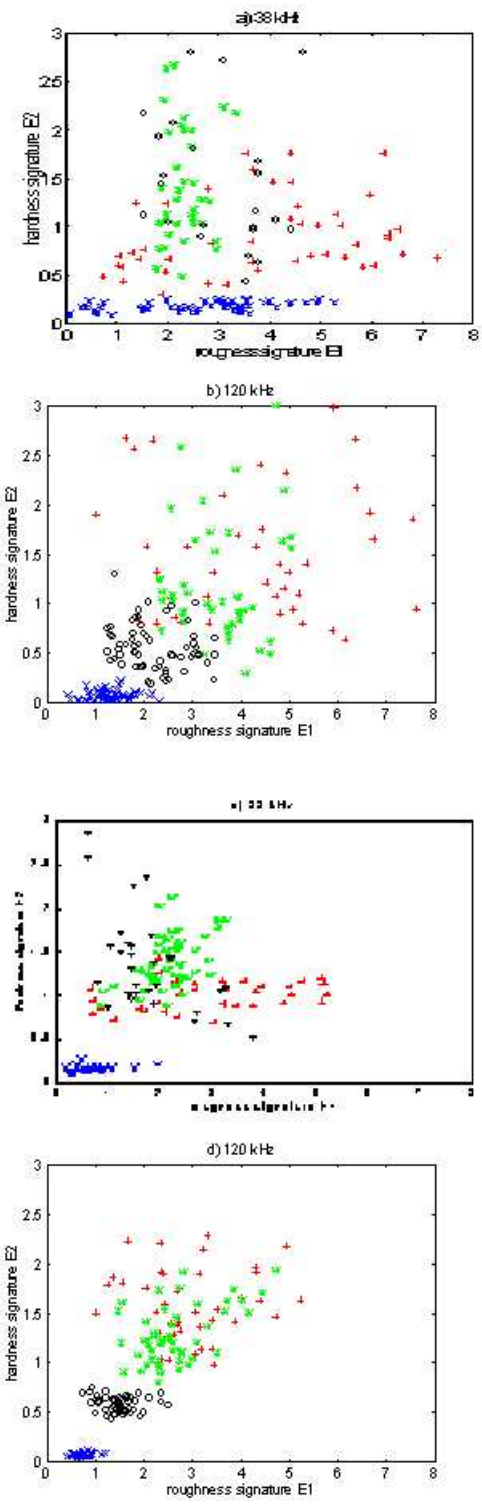

Figure B.6: Classification results for the second echo method:a), b)pulses with maximum amplitude, c), d) averaged for all pulses (+ rock,* sand, o soft sand, x soft mud

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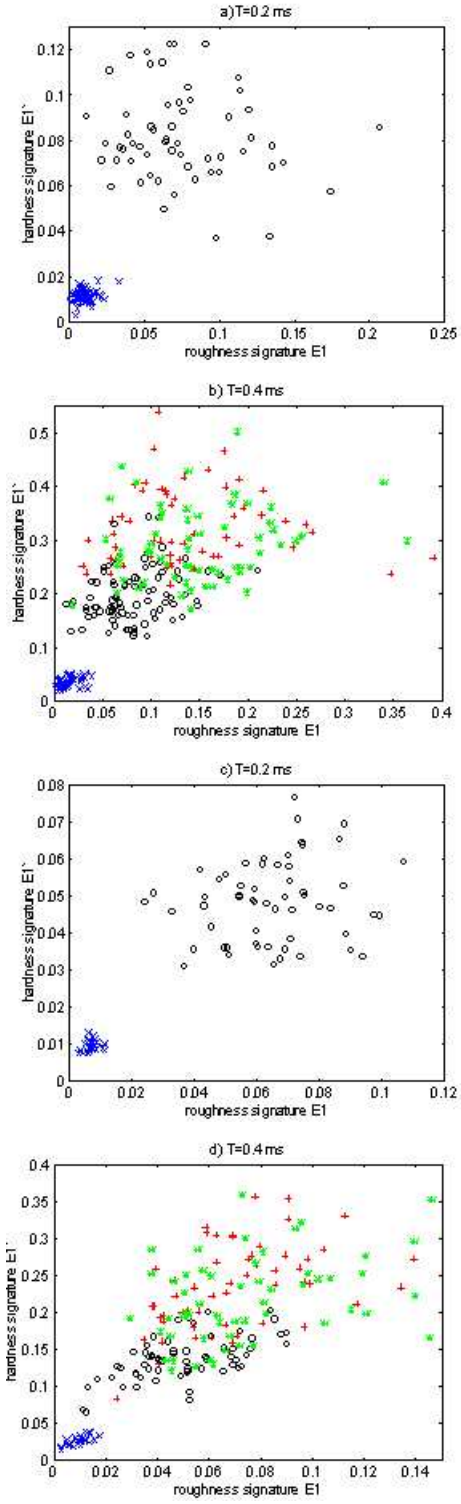

Figure B.7: Classification results for the second echo method: (frequency 420 kHz) a),b)pulses with maximum amplitude, c),d) averaged for all pulses (+ rock,* sand, o soft sand, x soft mud

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An additional set of 420 kHz data was analyzed in order to find the relationship between bottom hardness and roughness signatures and the grain size of bottom sediments. The percent of particles of different grain size is given in the table below (files PEPIN from Bruce Sable). Core samples of the upper part of the bottom (10 cm thick) were taken.

Table B.1: Percentage contents of particles of different size in bottom samples.

# of sample	**% of particles** $> 50\ \mu$m	**% of particles** $2\ \mu$m $<$X$<$ $50\ \mu$m	**% of particles** $< 2\ \mu$m
1	10,0	65,0	25,0
2	45,0	37,5	17,5
3	no data	no data	no data
4	52,5	35,0	12,5
5	22,5	55,0	22,5
6	22,5	55,0	22,5
7	15,0	62,5	22,5
8	17,5	62,5	20,0
9	no data	no data	no data
10	10,0	67,5	22,5
11*	97,5	-2,5	5,0

mainly mussels and fragmented mussels, percentage contents is not valid for this sample.

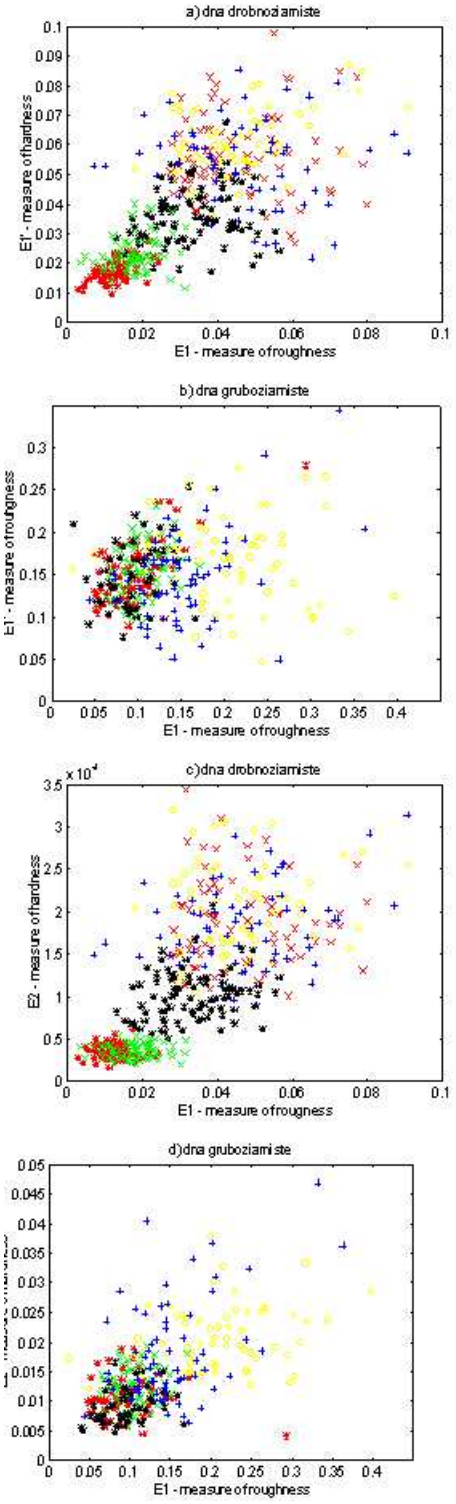
a) dna drobnoziarniste
E1' - measure of hardness
E1 - measure of roughness
b) dna gruboziarniste
E1' - measure of roughness
E1 - measure of roughness
c) dna drobnoziarniste
E2 - measure of hardness
E1 - measure of roughness
d) dna gruboziarniste
E1 - measure of roughness

Figure B.8: Classification results for bottom of different grain size: (frequency 420 kHz, pulses with maximum amplitude) a),b)first echo division method, c),d)second echo method. (a, c: fine grain: * - 1, x - 5, o - 6, + - 7, * - 8, x - 10, (b, d: coarse grain: * - 2, x - 3, * - 4, o - 9, + - 11)

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For this set of 420 kHz data both first and second bottom echoes were recorded and therefore analysis was done using first bottom echo division method and also first/second bottom echo ratio (Fig. 7).

B.4 Discussion

As indicated in the figures, it was not possible to obtain a complete separation of areas occupied by different classes of the bottom in any of the cases. For both methods (first echo division and first/second bottom echo ratio) the classification results are better for the frequency 120 kHz. This effect is probably due to less contribution from volume reverberation in this kind of signal at 120 kHz than at 38 kHz. In figures 5d and 6d, we can see good separation of following types of the bottom: soft sand, soft mud and sand.

For low frequency (38 kHz) and also for high frequency (420 kHz), we can observe improvement in separating the most class of the bottom with the pulses of longer duration ($\tau = 0.4$ ms). However, harder types of the bottom were more difficult to separate. In the case of 420 kHz data set, the reason may be that the bottom classes were not the same as for 38 kHz and 120 kHz (soft mud, soft sand) while mud and mud with sand were used at 420 kHz. Scattering diagrams demonstrate that the bottom mud with sand has similar properties to rock and sand bottom rather than to soft sand.

Results for 420 kHz with pulse duration $\tau = 0.4$ ms correspond only to two bottom classes i.e. mud and mud with sand (Figs. 7a and 7c). The separation between these bottom classes is rather good. However this was to small data set (only two bottom types) in order to draw conclusion on influence of pulse duration on bottom classification results for 420 kHz. It will be necessary to acquire more data on this topic.

The worst separation occurs (in all of the cases) for the rocky bottom. It is caused by the highest value of the parameters scattering in the case of this type of the bottom. This scattering is the result of the big dynamics of the signal changes even in the case of slightly different incidence angles related to the bottom unevenness.

Comparing classification results for the pulses with maximum amplitude with the averaged ones for all of the pulses it can be noticed that selection of the pulses with maximum amplitude improves differentiation in case of the method with division of the first echo signal. It is visible both in all frequencies (38 kHz, 120 kHz, 420 kHz).

In the case of the second echo method (for 38 kHz and 20 kHz) it can be seen that differentiation is improved for the averaged results, though averaging caused, visible in both methods, decrease of roughness and hardness measures as well as the dynamics suppress. This change is caused by the contribution in the averaged results of pulses scattered at oblique incidence from the bottom (caused by tilt of the boat and transducer). These pulses are characterized with a smaller amplitude than those from the normal incidence.

Estimation of bottom class for PEPIN data set (the one with percentage contents of particles of different size) is rather

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difficult since there is no available relationship between bottom class and the percentage particles contents. Although we have no explicit description of bottom samples there are some regularities in relationship between hardness & roughness signatures and particles contents.

The bottom particles size was divided into three groups: coarse grain (more than 50 μm), medium ones with (from 2 μm to 50 μm) and fine grain (less than 2 μm). The content of fine particles (less than 2 μm) is approximately the same in all samples. Than bottom classes can be divided into two classes of percentage content of fine particles: coarse grain (samples 1, 5, 6, 7, 8, 10 and fine grain (samples 2, 3, 4, 9, 11).

The bottom classification analysis (hardness & roughness signature) demonstrates that experimental data PEPIN can be grouped into two clusters, which was visualized by choosing two different scales on graphs on the Fig. 8.

Regions with data points for different groups with partial overlap make bottom classification more difficult. However we can not say whether the reason is the deficiency of the method or whether just samples of bottom classes are overlapping. IT is likely that bottom on similar grain size produces acoustic samples with hardness & roughness signature close to each other (e.g. samples 1, 10 or 5, 6, 7). Fig. 9. presents PEPIN data pints divided into two classes of the bottom: fine grain and coarse grain.

Similar as to data analyzed for 38 kHz and 120 kHz also for 420 kHz frequency data signals of larger amplitude have lager variability (e.g. bottom samples 9 and

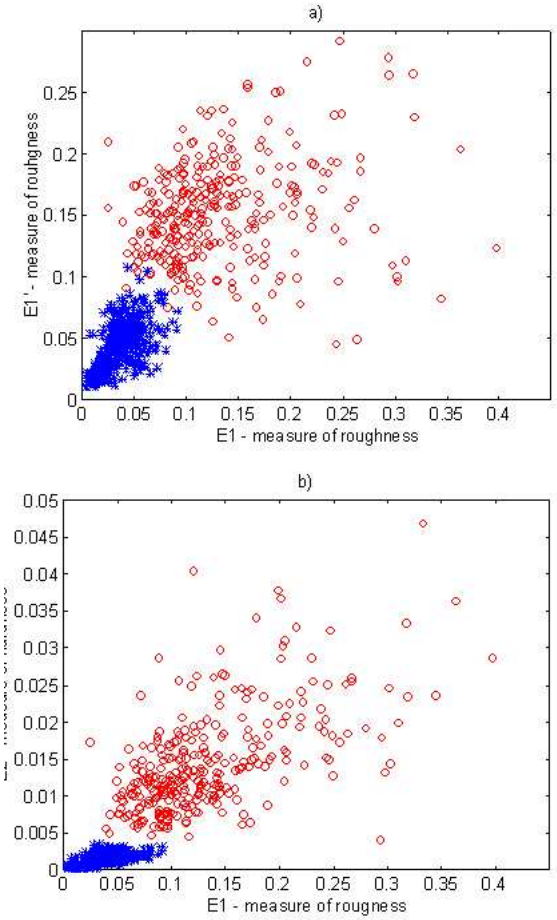

Figure B.9: Classification results for bottom of different grain size: (frequency 420 kHz, pulses with maximum amplitude)a) method of division of first echo, b) second echo method.(o - coarse grain, + - fine grain)

11). One can expect that those signals correspond to the hardest and most uneven bottom surface. Experiments showed that the method with the division of the first echo signal gives comparable results with those obtained from the second echo method. In the case of a normal incidence the results are even better. Its advantage is that it does not need the second echo signal, which can be obtained

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only by special range adjustment in the echosounder. In most of the cases (deep seas, soft bottom types) a high dynamics echosounder is required for that purpose.

In relation to other methods of sea bottom classification, using for example neural networks or cluster analysis, presented method characterizes with a big computing simplicity. It enables the method to be implemented in a portable system (on board of the research vessel), working in the real time. The advantage of the method is also the fact that it has no time-consuming learning phase and there is no need to use a great amount of data for it.

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Appendix C

Method B4 - Publication

Sea bottom typing using fractal dimensions

vspace.1in Z. Lubniewski & A. Stepnowski
Technical University of Gdañsk, Acoustics Department, 80-952 Gdañsk, Poland

Paper published in Proceedings of the International Symposium on Hydroacoustics and Ultrasonics. Gdansk-Jurata, Poland, 12-16 May 1997.

C.1 Summary

The article presents an attempt to apply elements of fractal analysis for the purpose of sea bottom typing. The fractal dimension was calculated as box dimension for sampled envelopes of echo signals from four types of sea bottom recorded during mobile acoustic surveys carried out in Lake Washington. The results obtained show that the simple method applied can be used for on board sea-bed recognition in real time with accuracy similar to that of other methods.

C.2 Introduction

Sea bottom identification methods have a wide range of applications in hydrography, marine engineering, environmental sciences, fisheries and other domains. Acoustic methods which use the information retrieved from the acoustic bottom echo, have advantages over the other methods (e.g. geological cores or remotely operated vehicles with TV cameras), as being non-invasive, more cost effective and faster. In general, the following approaches are used in the acoustic methods of bottom typing:

- measurement of energy ratio of the first and second bottom echo (so called "RoxAnn" method) [2],
- comparison of the actual cumulative echo envelopes with theoretical patterns [5],
- analysis of a set of values of acoustic and statistical parameters of the echo envelope using cluster analysis or neural networks [6], [7],
- division of the first echo signal [1].

It is known that the surface of sea bottom is an example of a naturally-occurring fractal structure[3]. Taking this into consideration, as well as the fact that fractal dimension is a measure of complexity, the authors made an attempt to use fractal dimension of the recorded echo envelopes in order to perform sea bottom-typing. The implicit assumption here was that fractal structure of the bottom is transferred onto sort of its image observed in the form of an envelope of a sonar echo.

C.3 Fractal analysis

In the course of examining and describing the elements of nature, it was found that the shape and structure of naturally-occurring structures cannot usually be defined in terms of Euclidean geometry. That is why this kind of geometry is not the most adequate tool to describe this

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type of elements. On many occasions, however, nature has proved to accommodate various types of elements with fractal structure (e.g. the structure of plants' leaves, corrugated sea surface or bottom surface [3]) which suggests that fractal analysis methods are the proper methods to study and describe such elements.

Fractal sets are defined as scale-invariant (self-similar) geometric objects. A geometric object is called scale-invariant, if it can be written as a union of rescaled copies of itself. Regular fractals, such as the Cantor set, Sierpiski triangle or Koch snowflake (which is shown in Fig. 1), display exact self-similarity [3], [4]. Random fractals display a weaker, statistical version of self-similarity.

When we want to measure the size of fractal figures, we encounter problems. We are not able to measure the size of such figures using standard methods. The Koch Snowflake, for instance, has a surface equal to zero (we mean the side of this figure), but its length tends to infinity when the size of the measuring step tends to 0.

The Hausdorff dimension [3], [4] may be the solution of this problem, as it can be used as a measure of many very general sets, including fractals. The Hausdorff dimension of a subset X of Euclidean space is defined as a limit

$$D = \lim_{\Delta s^1 \to 0} \frac{-\log N(r)}{\log r} \qquad \text{(C.1)}$$

where N(r) denotes the smallest number of open balls of radius r needed to cover X.

The open ball B(p, r) = {x: dist(x, p) < r}, where dist(x, p) is the distance between points x and p. For example, the Koch snowflake has the Hausdorff dimension equal to log 4 / log 3 ≈ 1.262.

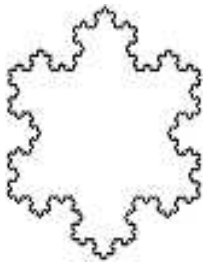

Figure C.1: The Koch snowflake, constructed as a limit of a sequence of simple iterative steps.

Starting with the equilateral triangle, each consecutive stage is constructed by replacing line segments with copies of the figure:

In the random version, in each stage the replacement by:

or

may be made, with probability of 0.5 for each case.

It is clear that the dimension (as defined above) is the measure of the complexity of a given figure and we could apply it to measure the complexity of the shape of a digitized echo pulse from the sea bottom. It should be the indicator of the complexity and also the type of sea bottom. The shape of a digitized echo pulse, as it consists of a finite set of straight sections, is not really fractal. However, we can evaluate this dimension for such echo pulse not as a limit, but for a finite, fixed value of r.

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C.4 Materials and methods

The bottom echoes data we used to calculate the fractal dimension were recorded in the water region of Lake Washington with the use of a digital DT4000 BioSonics echosounder with two operating frequencies: 38 kHz and 120 kHz. Simultaneously, the current position of the ship was registered using the GPS system. Data acquisition was performed both while the ship was moving along the selected transects, and while the ship was anchored. In each case the type of sea bottom in the given water region was known. This enabled a verification of the applied method of bottom typing. The length of the pulse sent by the echosounder was 0.4 ms and the sampling frequency was equal to 41.66 kHz.

It is not easy to calculate the fractal dimension of a figure following the definition of the Hausdorff dimension. Therefore we decided to use the box[2] dimension [3], that can replace the Hausdorff dimension for many sets, including shapes of our echo pulses. The box dimension for a figure on a plane is defined as follows. Let N(Δs) denote the number of boxes in a grid of the linear scale Δs which meet the set X on a plane. Then X has a box dimension

$$D = \lim_{\Delta s \to 0} \frac{-\log N(\Delta s)}{\log \Delta s} \qquad \text{(C.2)}$$

The method of evaluating the box dimension of the bottom echo envelope is explained in Fig. 2.

We evaluated the box dimension D for the finite value of Δs = 1/ 36, that is, there were 36 boxes both horizontally and vertically on the area of the echo waveform plot. Each echo pulse was normalized to the standard length and height and afterward the number of boxes N(Δs) was counted as shown in Fig. 2. The box dimension was evaluated according to formula (2) (without using the limit). The amplitude threshold used for the analyzed signals was -70 dB. The box dimension was calculated for each echo pulse separately, and histograms of its values for each type of bottom were constructed and analyzed.

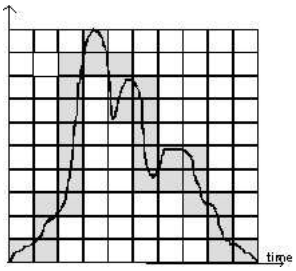

Figure C.2: Illustration of the box dimension evaluation. In the considered case, Δs = 0.1, N(Δs) = 30.

C.5 Results

Figures 3, 4 and 5 show the histograms of box dimension values obtained for echo pulses for four types of bottom. Three sets of acquired data were analyzed: stationary data of echosounder frequency 120 kHz and 38 kHz and data from transects data of echosounder frequency 120 kHz. In each case, more than 600 pings for each bottom type were taken for the calculations. For stationary data, apart from analyzing the distribution of values of box dimension for all pulses, 10% of pings of the highest amplitude were se-

[2] EDITOR'S NOTE: for simplicity, the authors' term 'box dimension' may be considered equivalent to the fractal dimension (CJC)

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lected in order to take into account only the echoes from pulses with the most likely normal incidence to the bottom and to drop the others, reducing the effect of a ship's pitching and rolling. However, it is easy to observe that this operation had no significant impact on the results.

The presented histograms show that in the case of the 120 kHz frequency of the echosounder (Fig. 3) there is a clear difference between the values of the box dimension for a rocky bottom and for other types of sea bottom, especially for the data collected from the anchored ship. In the case of rock the box dimension values are much higher (which is in line with expectations), because the surface of a rocky bottom is more corrugated and irregular. For the other types of bottom, the obtained box dimension values at a 120 kHz echosounder frequency do not allow for a clear distinction between them. However, in the case of the data obtained from transects, the general regularity is evident, namely that the harder the bottom is the higher the box dimension values.

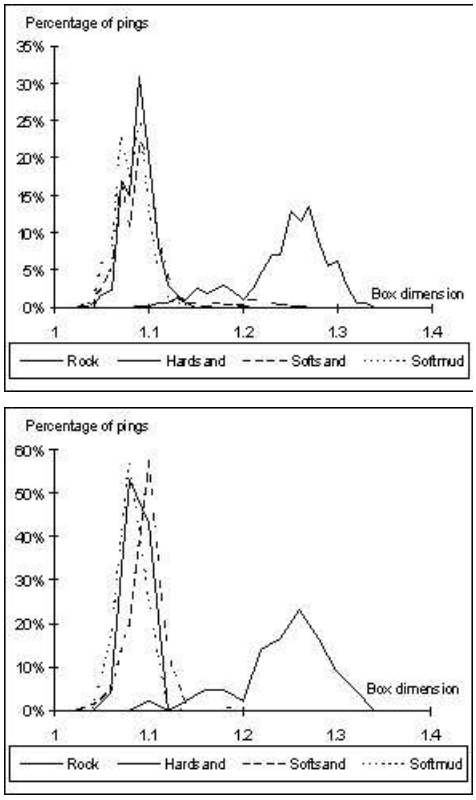

Figure C.3: The histogram of the box dimension values evaluated for echo pulses from stationary data for the echosounder frequency 120 kHz: a) for all echo pulses, b) for selected 10% of echo pulses of the highest amplitude level

What is interesting is the bimodal distribution of box dimension values for echo envelopes for rocky bottom for the data from transects (Fig. 5). This form of distribution is due to a recording made in transects of alternating series of pulses of a twofold shape. The examples of oscillograms of two classes of echo pulses from the transects are presented in Fig. 6. The existence of these two echo pulse types may be explained by alternative reception of echo signals reflected at normal incidence (specular reflection) and echo pulses received at oblique incidence. The first type pulses have higher amplitude and less fluctuating envelope shape, against the higher amplitude and more fluctuating envelope shape of the second type pulses (see Fig. 6).

In the case of the 38 kHz echosounder frequency (Fig. 4), where the only data available was data from the anchored ship, there is a clear division between box dimension values obtained for various types of bottom.

However, the mutual relations between them are not in line with the expectation

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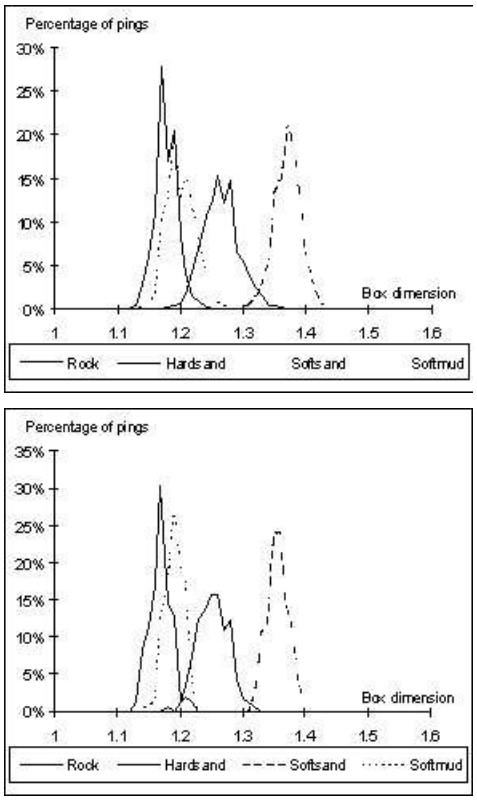


Figure C.4: The histogram of the box dimension values evaluated for echo pulses from stationary data for the echosounder frequency 38 kHz: a) for all echo pulses, b) for selected 10% of echo pulses of the highest amplitude level

that echo envelopes from a bottom with higher hardness should have a higher value of the fractal dimension. This may be due to the fact that when pulses at this frequency are reflected from the bottom, for certain reasons the fractal structure of the bottom may fail to transfer itself onto its image in the echo envelope.

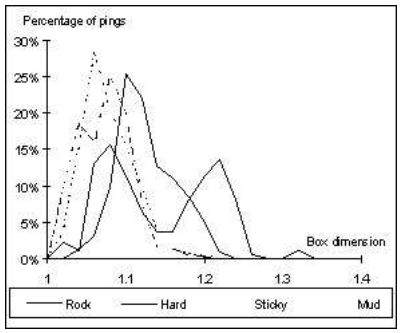
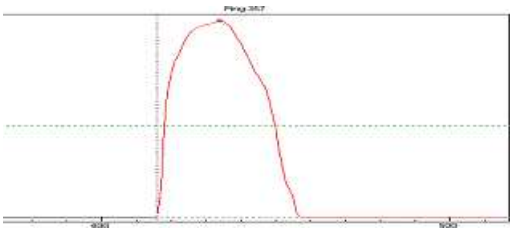
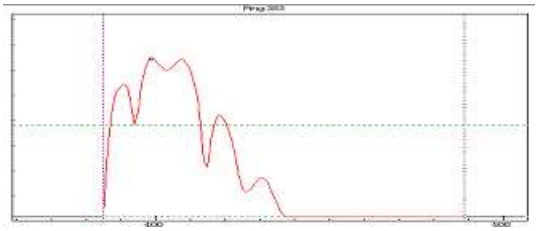


Figure C.5: The histogram of the box dimension values evaluated for all echo pulses acquired from transects, for four types of bottom, at the echosounder frequency 120 kHz



a) the echo pulse from the first class



b) the echo pulse from the second class

Figure C.8: Sample oscillograms of two classes of echo pulses, recorded for the rocky bottom from transect

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C.6 Conclusion

The results of the presented investigation are promising, as they show that evaluation of fractal dimension may be a usable method of bottom typing. The results are not worse than those obtained concurrently using other methods. However, it must be noticed that the data used were restricted only to one relatively small water region, so the method should be verified for a larger area and for different parameters of data acquisition. In this work the authors assumed, that fractal structure of the bottom surface transfers itself onto its image in the echo envelope. It is the authors' opinion, however, that an extension of the applied method could be the application of the deconvolution of scattering impulse response of seabed from bottom echo, before the fractal dimension is calculated.

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Appendix D

Factory Settings for Configuration File VBT.ini

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[Reports]
Pings=20
Percent=60
Averaging=1

[RectLibrary01]
E1Min=-60.00000
E1Max=-10.
E2Min=-60.00000
E2Max=-20.
No=3
Rect1=43,124,111,150
Rect2=96,94,142,141
Info00=SN 4908, 0.4 ms, BTr. 20 log, BW 16, 48, 50, 100, 16
Info01=MUD120.DT4 red (Bot. Type 1), 120 kHz
Rect3=115,52,167,111
Info02=SAND120.DT4 green (BT 2) , ROCK120.DT4 blue (BT 3)
Info04=

[Method 2]
E1Max=-10
E2Max=-20
E1Min=-60
E12Min=-60
LinLog=1
PointSize=2

[Echo window size]
Rect=0350 0006 0631 0255
icon=0
max=0

[Options]
Echogram Size=171
B1MaxError=0.07
```


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```
bthreshold=-50
bthickness=5
sthreshold=-69
sthickness=1
alarm=8
bwindow=66
domain=0
TVG=0
depth=1
lin=0
blength=48
blength2=100
subbottom=50
bottomOffset=16
initialoffset=0
grid=0
ticks=1
threshold=1
fillbottom=1
bottoms=1
CalcBottom=1
B2rescale=1
B3rescale=1
StopIt=0
SimradScope=0
OutputDateFormat=1
LatLonFormat=0
Separator=0
colorbar=-70 3 -30

[Results window size]
Rect=-002 0264 0770 0401
icon=0
max=0

[Scope window size]
Rect=-003 0008 0342 0262
icon=0
max=0

[Colors]
Templates=255 65280 16711680 16711935 8388736 8388736 8388736
```

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```
8388736 8388736 8388736 16711935 8388736 8388736 8388736 8388736 8388736
Echo=0 0 0
Grid=0 0 255
Chart=255 255 255
Level=0 128 0
Bottom=128 0 128
Bottom2=128 0 0
#Current=0 64 4210816 255 8421631 16384 65280 8454016 4210688
8404992 16776960 16777088 8553090 12632256 16777215 16777215
Current=0 4210816 255 8388863 16711935 4227327 65535 32768 65280 65408 8388608
 16711680 16776960 16777215 16777215 16777215
Palettized=0

[Rect5Library01]
No=3
Rect1=41,75,97,122
Info00=120 kHz, 0.4 ms, SN 49408, BotWin 16, 48, PL 16
Rect2=90,33,138,79
Info01=MUD120.DT4 red (Bottom Type 1),
Info02=SAND120.DT4 green (T 2), ROCK120.DT4 blue (T3)
Rect3=132,16,171,76

[Rect6Library01]
No=3
Rect1=8,91,99,151
Rect2=72,59,142,93
Rect3=113,28,176,60
Info00=120 kHz, 0.4 ms, SN 49408, BotWin 16, 48, PL 16
Info01=MOD120.DT4 red (Bot. Type 1)
Info02=SAND120.DT4 green (T2), ROCK120.DT4 blue (T3)

[VBT Files]
;C:\BIOSONICS\VBT\CTLG\ROCK120.DT4=-43 -69 50 16 48 100 0|-23870
55.9157 5 222 -58 0.4 120000 1490.34 0 6 0.000990972 -70 -70 49408
;C:\BIOSONICS\VBT\CTLG\SAND120.DT4=-48 -69 50 16 48 100 0|-23870
55.9157 5 222 -58 0.4 120000 1490.34 0 6 0.000990972 -70 -70 49408
;C:\BIOSONICS\VBT\CTLG\MUD120.DT4=-50 -69 50 16 48 100 0|-23870
55.9157 5 222 -58 0.4 120000 1490.34 0 6 0.000990972 -70 -70 49408
;C:\BIOSONICS\VBT\CTLG\MUD420B.DT4=-55.0047 -69 50 16 48 100 0|-23870
56.0601 2 218 -51 0.2 420000 1486.5
;C:\BIOSONICS\VBT\CTLG\SAMD420B.DT4=-55 -69 50 16 48 100 0|-23870 56.0601
 2 218 -51 0.2 420000 1486.5
```

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```
;C:\BIOSONICS\VBT\CTLG\MUD420.DT4=-63 -69 50 0 24 100 0|-23870 56.0601
 2 218 -51 0.2 420000 1486.5
;C:\BIOSONICS\VBT\CTLG\SAND420.DT4=-55 -69 50 0 24 100 0|-23870 56.0601
2 218 -51 0.2 420000 1486.5
;C:\BIOSONICS\VBT\CTLG\MUD120.DT4=-48 -69 50 16 48 100 0|-23870 55.9157
5 222 -58 0.4 120000 1490.34
;C:\BIOSONICS\VBT\CTLG\TR7_B.DT4=-54 -69 50 16 48 100 0|-23870 55.9157
1 222 -58 0.4 120000 1490.34 0 6 0.000990972 -70 -70 49408
;C:\BIOSONICS\VBT\CTLG\ROCK120.DT4=-40 -69 50 16 48 100 0|-23870 55.9157
5 222 -58 0.4 120000 1490.34
;C:\BIOSONICS\VBT\CTLG\MUD120.DT4=-57 -69 50 16 48 100 0|-23870 55.9157
5 222 -58 0.4 120000 1490.34
;C:\BIOSONICS\VBT\CTLG\TR7_B.DT4=-53 -69 50 16 48 100 0|-23870 55.9157
1 222 -58 0.4 120000 1490.34
SAND120.DT4=-53 -69 50 16 48 100 0|-23870 55.9157 5 222 -58 0.4 120000
 1490.34
ROCK120.DT4=-40 -69 50 16 48 100 0|-23870 55.9157 5 222 -58 0.4 120000
 1490.34
TR7_B.DT4=-53 -69 50 16 48 100 0|-23870 55.9157 1 222 -58 0.4 120000
 1490.34
MUD120.DT4=-53 -69 50 16 48 100 0|-23870 55.9157 5 222 -58 0.4 120000
 1490.34


[Window size]
Rect=0085 0064 0712 0483
icon=0
max=1
tool=1
status=1

[Recent File List]
File1=C:\BIOSONICS\VBT\CTLG\MUD120.DT4
File2=C:\BIOSONICS\VBT\CTLG\SAND120.DT4
File3=C:\BIOSONICS\VBT\CTLG\ROCK120.DT4
File4=C:\BIOSONICS\VBT\CTLG\TR7_B.DT4

[Method 3]
E1Max=-10
E2Max=-10
E1Min=-50
E12Min=-50
```

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```
LinLog=1

[Rect5Library01]
No=4
Rect1=62,70,97,109
Rect2=94,45,130,74
Rect3=41,13,73,34
Rect4=115,31,147,54
Info00=120 kHz
Info01=FBW30, 60%, 20p
Info02=red SMUD, green SSAND, blue HASAND, pprp ROCK
Info03=leaveonly SSAND


[Library01]
No=2
Ping10=0.0049,0.0141,0.0273,0.0461,0.0745,0.1166,0.1752,0.2523,0.3436,0.4365,
Ping11=0.5205,0.5903,0.6492,0.7059,0.7606,0.8099,0.8521,0.8869,0.9185,0.9485,
Ping12=0.9721,0.9867,0.9951,1.0000,
Info00=420 kHz, SN49522, 6 deg. PL 0.2 ms
Info01=B.Windows:  0, 24, 50, 100, 8
Info02=red:1 MUD420.DT4, green: 2 SAND420.DT4
Ping20=0.0003,0.0029,0.0178,0.0613,0.1405,0.2473,0.3718,0.5098,0.6531,0.7789,
Ping21=0.8640,0.9087,0.9330,0.9518,0.9688,0.9814,0.9883,0.9919,0.9946,0.9971,
Ping22=0.9988,0.9996,0.9999,1.0000,

[Method 4]
XMax=1.10001
YMax=0
XMin=0.9
YMin=-60
LinLog=1

[View]
Map=0

[Map window size]
Rect=0101 0024 0591 0414
icon=0
max=0

[Map]
```

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```
Zoom=1

[Map Files]
TR7_B.DT4=map\mapa.bmp,47.7177,-122.637,47.6997,-122.596,1,11,0
MUD120.DT4=map\emptymap.bmp,0,0,1,1,1,0,0

[HASP]
Key=1972

[install]
user=Generic
company=Generic
serial number=144-4490-204
just_installed=0
```

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